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ABSTRACT

Included are edited transcripts of a number of individual interviews with randomly selected high school biology students presented for educators who wish to study inquiry processes. Students were introduced to an interesting, but unexplained biological phenomenon through a brief printed account. They were asked to state how they would proceed to investigate a possible explanation of this phenomenon. They could ask the resource person (a staff member from a wildlife center or university) for any information which would ordinarily be found in a scientific report, but could not expect procedural guidance from him. Topics were as follows: unexplained bird mortality, food preferences of newly hatched snakes, bird aggression, and birth defects in two isolated villages in Central America. Each interview lasted about one hour. [Not available in hardcopy due to marginal legibility of original document.] (Author/AL)

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INQUIRY STRATEGIES OF HIGH SCHOOL BIOLOGY STUDENTS

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

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Summary

The Mid-continent Regional Educational Laboratory has collected interview data on the procedures followed in a "dry run" inquiry by a small number of randomly-selected high school biology students. Acting as resource persons during these dyadic interviews were staff members' from area wildlife study centers and universities.

Students were introduced to an interesting but unexplained biological phenomenon through a brief, printed account presented to them by the resource person. They were asked to state how they would proceed to investigate a possible explanation for this phenomenon. They could ask the resource person for any information which would ordinarily be found in a scientific report, but could not expect procedural guidance from him. Topics were as follows: Unexplained Bird Mortality, Food Preferences of Newly-Hatched Snakes, Bird Aggression and Birth Defects in Two Isolated Villages in Central America.

Each interview lasted approximately one hour. Edited transcripts are being submitted for publication in the ERIC system in order to make these original protocols available to members of the educational community who wish to study inquiry processes.

Categorization of these interview processes as to inquiry process manifested in each quarter of the interview will be carried out and reported at a later date.

Introduction

The Mid-continent Regional Educational Laboratory has as its focus the encouragement of effective methods of teaching pupils inquiry skills in high school biology. The task of measurement of inquiry skills is difficult because one cannot measure inquiry as one would measure correct knowledge of facts or psychomotor skills. Because the staff at McREL had searched for an appropriate test of the skills used in an inquiry process and had found none, they determined to build a test of inquiry ability which would sample at least some of the skills employed by a student in investigation in biology. This paper consists of the transcripts of tape recorded interactions of students and resource persons, in which students verbalized the strategies they would adopt in conducting an inquiry into a puzzling question. The procedure followed was this:

First, the interests of students midway through a course of biology at the high school level were surveyed. From this list of interests, several topics were chosen which seemed to have a broad appeal to students in a variety of schools. Second, readings on these topics were excerpted from such authoritative and readable sources as Science News, Scientific American, Encyclopedia Britannica, Biological Science Information Service, and specialized texts. Third, a selection of (a) highly informative (b) somewhat informative, and (c) irrelevant readings was made. A reading list of resources in a given topic area was complied. Fourth, scholars in these areas of research were contacted; they agreed to act as additional "data banks" in an interview with a student. Fifth, arrangements were made for students in a high school* class in biology to conduct a "dry run"

* a middle-class, archdiocesan high school

investigation asking of these resource persons any information that the student deemed relevant. Sixth, these interviews were then made available to a team of writers for use in constructing multiple-choice problems on each topic, for assessment of students' inquiry ability at the beginning and the end of the sophomore course in biology. The interviews were used as general guidelines to indicate the trend of thought which occurred spontaneously when students grappled with a novel problem, having at their disposal of rich array of information.

Every effort was made to encourage interviewers to be as non-teaching and non-directive but informative as possible within the scope of the interviewer's ability and knowledge. However, it must be acknowledged that some degree of interviewer direction entered the proceedings when students expressed helplessness in knowing what to do next. The breadth of knowledge communicated to the students at some points went beyond the scope of the information requested by the student. This would not happen in an instance where the student was interacting with a computer, but it was felt that the face-to-face situation had much to recommend it in that the interviewer was able to be much more sensitive to the needs of the student than would a computer.

The topics which were selected for presentation to the students were as follows:

1. Bird mortality increasing without apparent cause over a ten-year period.
2. Persistent food preferences of newly hatched snakes with no apparent opportunity to learn tastes for particular foods.

3. Aggressive behavior in the redwinged blackbird, varying with the species of the stimulus bird.
4. Occurrence of unusually high ratio of crippling deformities in both children and adults in a tribe of Central Americans who appear to be ritual users of a hallucinogenic drug.

This report, then is being made of the free responses of these students during these interviews with highly qualified resource persons drawn from the staffs of a specialized center for wildlife study or from area universities.

Consultants Cooperating in the Interviews

The consultants who acted as resource persons were as follows: Dr. Robert B. Finley, Jr., Wildlife Ecologist, Denver Wildlife Center, Denver, Colorado whose cooperating in this activity was made possible through the Public Information Service of the Denver Wildlife Center; Dr. Linda Trueb, Research Associate, Museum of Natural History, University of Kansas, Lawrence, Kansas; Dr. William Duellman, Professor of Systematics and Ecology, University of Kansas, and Curator of Herpetology, Museum of Natural History, University of Kansas, Lawrence, Kansas; and Dr. Wayne Reeve, Professor, Department of A Anatomy, School of Dentistry, University of Missouri at Kansas City.

Dr. Frank Neff, Associate Director for R&E, McREL, acted as co-interviewer during the bird mortality problem since this was the prototype interview on which others were to be based.

The students involved in exploring the bird mortality problem were interviewed in February and had been enrolled in a course in biology extending over the entire school term. Students who responded to the snake food preference, redwinged blackbird aggressive behavior, and birth defects problems were interviewed two months after the beginning of the school term and were also students in the first year class in biology.

Purpose of Publication of these Transcribed Interviews

We believe others in the educational community may share our interest in building programmed materials based on inquiry processes as revealed in the natural flow of students' remarks or sequence of questions asked when presented with a given unexplained phenomenon. It was felt, then, that a publication of the transcripts of students' verbalized thought processes given in relatively unstructured setting in which to carry out inquiry would be of interest to others.

Format of This Presentation

The typed paragraphs introducing the problems which were presented to different students are shown at the beginning of the chapter containing interviews on each topic. The interview proceedings are presented as outlined above with the symbol S standing for student, and I standing for interviewer response.

Wherever obvious repetition or unintelligible recording of the interaction was encountered, editing was carried out. Editorial consolidation of comments by the interviewer was carried out wherever possible. Relatively little editing of students' remarks was done in order to provide protocols which truly represented thought processes of students as they launched simulated investigations of a puzzling question.

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Chapter I

Interviews Regarding Unexplained Bird Mortality

Each student was oriented to the nature of the task by the interview team members, who explained that the purpose of the interview was to find out how students went about the process of scientific investigation of puzzling phenomena. They were told they could ask the team members for information which might be found in published reports on the subject under consideration.

The student was then given a card on which the following information was typed. Many more dead birds than usual were observed in a rural Midwest area each summer beginning in 1961 and continuing up to the present. These birds were of the same species.

Interview Number 1

Interviewer: Try to imagine that the situation we are working in is one where you can get at a really good library; it's got all kinds of information that a good library would have and we have laboratory facilities available so that you can ask most any kind of question. We have experts of various kinds that we can call on. They might not be here immediately, but we can go to them and get information or get them to help, so that you can pursue the problem and work on it in any way you would like. This kind of setting is different from lots of tests where there is a right answer and there is a wrong answer, there is a right question and there is a wrong question. Here, the question that ought to be asked is the one that is on your mind. So, however you go about doing this is going to help us develop materials that can be used by boys and girls to do a better job and learn faster some of the things they would like to learn. Now we'd just like you to think out loud about what you would do in trying to go to work on that problem, and remember that you have all these resources available and you just start going to work on it.

Student: Well, are there any particular type of birds that are dying out more than others?

I: Okay, now this is one of the questions that you would like to get some information about. Now supposing you have all these resources available. How do you suppose you would get an answer to that question?

S: First of all, I would make out a table and put down various birds, and then I'd look up and see how many birds have died in each category.

I: Which birds would you have in this table?

S: All the birds that have died, that have a percentage that have died. Second, I'd get some, I'd try to get a specimen of a dead bird to be examined in the laboratory and see exactly what makes them die, and then third, I'd make another table describing the age of the bird and see how many died, how young they are and how old they are.

I: How would you go about getting those birds?

S: Are we presuming that it is this time of year, or summer, or when?

I: Summer.

S: Then I would put an ad in the newspaper for anyone who finds a dead bird to send it to me.

I: Okay, you receive quite a few dead birds and they come from various addresses.

I: As a matter of fact you're inundated, now what shall you do?

I: You may get all kinds of dead birds. Some of them are fresh and some of them are spoiling, and some have broken wings, and in various conditions. Some come from Jackson County and some, you don't know for sure if they are Jackson County because they are mailed from the Kansas City Post Office. How would you go further?

S: I'd check with the Health Department and see what information they could give me about it, and if they have any available dead birds I'd use theirs first.

I: The Health Department would report that they have heard about these dead birds and they occasionally do have reports of domestic animals that sometimes die, chickens in barnyards and what not, but they don't have any explanation specifically of any incidence of dead birds and as far as they know, this hasn't been identified yet. They say that they are concerned about these deaths because they think it is possible that this is a human health hazard, and if there are any violations or regulations or restrictions regarding the use of any practice by the population that they would like to know about it, but they don't have any information they could tell us about why these birds have died.

S: Then I would try to get a nest of live birds and experiment with those and see if they will die. I'll get one of each type that I made the table on.

I: So then you would go out into the field and capture some of these birds, or would you take...you mentioned the ages...would you take adult birds, or would you take nestlings?

S: I'd take some of each.

I: And what would you do with them?

S: I'd make a large cage, about 8 feet high and maybe 12 feet long and put all these birds in there and simulate--put trees in back--and put plenty of food supply in there, and every once in awhile maybe every two or three days, examine the birds and see if they are becoming more sick or more healthy.

I: Now what kind of food would you put in? What other conditions would you presume? (This is presuming quite a bit, that you knew how to keep these nestlings alive--they are pretty hard to keep alive!) Presuming that you can feed the nestlings--it's pretty hard for a person to do as well as the mother bird does--you find out that nestlings have to be fed insects in rather large amounts, so you arrange to feed them earthworms and other insects. The adult birds, you feed either insects or prepared food like farm feed or grain and so on. And you provide water, since this is part of their requirement. As you keep the birds over a period of time, what do you want to know?

S: I want to see how...if it will take any time for the birds to die. I'd like to have a dead bird, a fresh, dead bird...

I: To run the pen test.

S. Yes.

I: Then when you have these dead birds, what will you do with them? Within a week a bird dies, and a couple days later another one. How many birds would you have in the cage, a hundred or so?

S: About 20, not too many.

I: So let's assume that five birds die.

S. I'd get five birds that have died and send to the laboratory with five other birds that seem like they are sick and compare the results and see if there is any virus or something that is in them that is killing them.

I: From the five birds from the same pen that are sick or not? Healthy or sick?

S: Sick.

I: Five dead birds and five sick birds and you send them to the laboratory and say to the laboratory, "Why did they die? or something like that?"

S: To see exactly what the trouble is.

I: The laboratory could conduct a bacteriological culture of the tissues to see if there is any kind of disease present. They report to you, "No, we did not find any, although one of them did apparently die of some kind of infection, but there was some evidence of malnutrition, too, and others the tests were negative. They died of something that we weren't able to identify as a specific cause from a disease." So the test comes back saying just this much, "There was no disease."

S: If you get a sick bird and inject the blood of the sick bird into a healthy bird, would that be possible to do without any bad results?

I: This is not very good. You might very well have a blood type reaction. You would have to do it in the same species and you might...the blood injection itself might very well kill the bird as well as transmit the disease. You would have some real problems here. I don't think this would give us a clear answer. I think we'd have an ambiguous result in which you couldn't say it was caused by the manipulation of the bird and the shock, or anything. But I'm wondering what conditions in your environment you would suspect would be causing these penned birds to be exposed. It is common practice that some birds will die over a period of time and this evidently happened in your test, but it doesn't

point toward a particular disease. Was there anything about these birds when you put them in that led you then to believe that you might have introduced a disease? Are you supposing that you might have picked up some birds that might have had diseases in the field to begin with?

S: Yes, I would have tried to.

I: And then you had some sick ones -

S: Yes.

I: Is there anything else that you would want to try to find out about them? I guess that the way the question went to the laboratory when you sent the five sick birds and the five dead birds, the question seemed to be saying, "Were these diseased birds?" When the answer came back they were not diseased birds. Is there anything else you would like to find out about those birds?

S: I'd try to find out where they are living, their environment, because it could be that something in their environment isn't right, like maybe the air has too much pollution or the water that they drink might have a lot of microorganisms in it, or the insects that they eat could be infected by pesticides.

I: How did you go about finding out that?

S: These are just hypotheses that...just saying that it might be...just investigating each one of these.

I: How would you investigate?

S: First, I would try to find out where these birds came from, where I got them, and try to find insects in the area and find out if any farmers are using pesticides. If he was I would see what the results of the pesticides would be on an insect when the insect is fed to a bird.

I: Would you talk to some of these farmers to try to find out what they are using, or what would you do?

S: I'd talk to them, ask them what kind of pesticides they are using, if they are using any.

I: Okay, the farmer tells you, "Well, yes we have used pesticides, we've sprayed our fields, our wheat fields with parathion to control pests. This has been common practice in the last few years."

Maybe in the meantime you still have these birds in captivity, which hasn't revealed very much. But you discovered the sick birds have now recovered and they are now healthy. This is what you might expect to find. Now what would you do?

S: Then I'd be wondering why these sick birds would recover and I'd probably... my first choice would be to see if it would be their food, because I'd be feeding them high grade food--food that doesn't have anything that's bad in it.

I: What do you know about your food? Does this...is this food that you obtained...you didn't get this food from the area where the birds are dying?

S: No.

I: This is ordinary, healthy food? You didn't put anything in it?

S: No.

I: How would you find out about the question? I guess the question we are asking is, "Is the food where these birds live good food?" How would you go about exploring that?

S: I'd have to collect some of the food that's around the area and examine it and feed it to healthy birds and see what happens.

I: You mentioned some insects..now we didn't identify the kinds of birds, but you did say you had a table of the kinds and presumably this includes several? We have in this pen, live birds of six or eight different kinds which have been dying and we're keeping them successfully--they're not dying in the cage, other than those first few sick ones. We have several kinds of food, some of these birds, say cardinals, are seed eaters and meadowlarks are insect eaters. We know that parathion has been used in the field. Now how would you go about finding out if this food is involved?

S: The first thing I'd do is get a sick bird and a healthy bird, one bird that is about to die but isn't dead yet, and a healthy bird and put them in a cage for a said time and if the bird recovers and the healthy bird doesn't get any disease then I'd know the disease, if it is a disease, isn't communicable.

I. As a matter of fact, you have this in your test to a certain extent only you have groups of birds. I said some of the sick birds recovered and I also said that none of the healthy birds that you put in there have come down with any illness. There hasn't been an increase in the number of sick birds in your cage except for the fact that a few die from time to time from old age or something.

S. Then I'd get two sick birds and put them in separate cages, feed one bird good food (my own choice of food) and feed the other one food from the area from which he was taken and see what results would come from it.

I: What kind of food from the area would you feed?

S: If it's an insect eater I'd probably...

I: Okay, let's say it's a meadowlark and you get some of the insects from the fields and feed them. Let's test this out. Both these birds are sick. It's quite likely, on the basis of using your expectation, that both birds would die. Now, even with fairly successful procedures of keeping a bird so that it has a fair chance of recovery, if the bird has symptoms under the conditions we are supposing now, a very likely result would be that the bird that was on healthy food might well have died as well as the bird that was on contaminated food.

S: Didn't we say before that the bird, some of the birds that were sick in the cage recovered?

I: Some of them did, but this one may not. Some of them also died when we first put them in there. The sick bird is a difficult bird to get data on. For one thing, we know something is wrong with both of those birds to begin with or they wouldn't be sick; and whatever it is that is wrong is sufficiently serious that we have not been able to correct the problem of mortality using the sick birds.

S: Then I'd have to get two healthy birds and perform the same experiment on them. But then I'd run into a problem because not all the birds in the area died and maybe these two healthy birds that I have, the one I feed bad food to might have stronger resistance and he won't die.

I: How would you handle that problem? Can you think of something you might do that would help answer the question you are asking?

S: Just feed them bad food and another thing I could do is to get my own grasshoppers or...

I: All right, as I understand it, you're concerned that if you take any food from this area, even using healthy birds, that both birds might die simply because whatever factor was killing them they have already been exposed to and also the fact that your food from that area may contain it.

S: Then I'd try to get the same type of birds, except from a different area of the country.

I: Okay, let's go out to the other side of Kansas City. There are other areas where we don't have any reports outside of Jackson County. Let's get some more meadowlarks from there and there are also similar farms and fields where one can go and get insects.

S: I'd get two birds from over there and feed them the same food I fed the birds from Jackson County.

I: I'm lost a little. Help me catch up. We had two birds from Jackson County and we had two birds from someplace else. I don't remember how they were fed. Were they all fed the same?

S: No, we get two birds from Jackson County and two birds from, say, Wyandotte County, adjacent to Jackson County. One bird from Jackson County and one bird from Wyandotte County were fed the same type of grasshoppers and other insects from eastern Jackson County where these sick birds were. The other two birds, the one from Jackson County and one from Wyandotte County were both fed healthy grasshoppers.

I: I misunderstood your setup. I thought you were feeding the birds from Jackson County entirely on Jackson County food and the birds from Wyandotte County were being fed entirely on Wyandotte County food.

S: No.

I: I see. You crossed the feeding. That's a good thinking process. Of the birds that were being fed on the questionable foods from Jackson County, let's say that the bird from Jackson County died and the bird from Wyandotte County did not die. Of the other pair, the bird from Wyandotte County, fed on your own food that was not contaminated, that bird survived, and the other bird also survived.

S: The bird that was fed on bad food from Jackson County died, right? And the Wyandotte County bird survived. Well, that will bring up another question because if two birds from Jackson County were from the same species, and one would die when fed the food of his environment and the other would live, that would bring up something to do with the food. It would also bring up that the bird from Wyandotte County that was fed this food may have some kind of resistance to it while the other bird from Jackson County maybe when it was brought up, since it kept constantly eating this food it just died because it had too much poison in its system.

I: How would you investigate that to find out if that is the case?

S: I'd probably have to make an analysis of its body to see if there were chemicals in it.

I: This is a good approach. Okay. We send these to a chemical lab. They tell us...how many birds would you have analyzed, all four?

S: No, just the one that died and the one that was fed bad...well, I'd have to have all four of them analyzed because I have to have some tests.

I: For the one that died, the report tells you "Yes, there was some parathion present, but not a great deal." We'll call it, two parts per million, and the one that was fed on Jackson County food and the bird that came from Wyandotte County had a trace of parathion a part per million, say two. That bird was still alive, and the other two birds that were fed on the clean feed did not have any. The Jackson County bird that had been raised in Jackson County did not have any.

S: Well, that would give me one conclusion that the food had parathion in it because the insects that were fed to the Wyandotte County bird... the Wyandotte County bird ended up having some parathion in its system.

I: Unfortunately, you got also a bird from Jackson County that does not have any and it's been feeding in Jackson County before you got it. The result isn't completely conclusive. I might volunteer this information, too. The chemical lab might tell you that chemical tests of parathion are not really too conclusive because it is not a long-lived pesticide like some of the others. It is a short-lived one. That means it breaks down. It decomposes into harmless materials over a period of a few weeks and if it's been sprayed and the birds are collected two or three weeks later if they had any parathion, it would have disappeared. So, the fact that a bird from Jackson County did not show it doesn't necessarily prove that it was not exposed to the chemical early. At the same time they feel that their chemical test is good enough that if it's made a short time afterward it will often identify the materials that's present although it isn't persistently accumulated.

S: Well, then, I'd put that experiment aside for the moment and I'd go back to Jackson County and get me another bird and have that bird analyzed to see how much parathion is in it as a control.

I: Where would you go in Jackson County? It's a big county and there are lots of different places. Not all of Jackson County is being sprayed. There are suburban areas, industrial, farming areas. Would you have any particular procedure... what are you trying to find? Are you trying to find that songbirds in Jackson County do have parathion in their tissues? Is that what you were looking for?

S: No, the bird that died that was fed bad food, that Jackson County bird...where I got that bird, I'd get me another bird.

I: So you'd go back to the same place? Okay. You'd get another bird. Let's suppose this one did have some parathion in it.

S: Then I'd know that the food has...

I: You'd have that examined right away. And it does have some parathion in it. Was that a dead bird or a live bird?

S: It was a live bird.

I: The chemical company would tell you, "Well, that shows that our parathion is not dangerous because it did not kill this bird, although there was some parathion in it."

S: I was going to ask you, how long does it take for it...the parathion... to kill a bird? How much would it take inside the bird?

I: Chemists would tell you that parathion is a quick-acting poison. It's not very persistent. It tends to break down within a matter of a few days usually, or at the most a week or so, but it acts ordinarily within 24-48 hours. If you expose it directly, the symptoms that you will see appear within a few hours are tremors and loss of coordination and ends with convulsions and paralysis. This type of symptom is characteristic of this whole group of chemicals and it's pretty good evidence that it's a cause of death.

S: Well, then I'd check the symptoms on those birds that I had on the bird that died that Jackson County bird and see if the symptoms were the same.

I: How would you check that?

S. I would have written down what would happen to the bird, beforehand.

I: Did your field notes show that you found some tremors? paralysis? Maybe I should be keeping that information, should I?

S: Yeah, I kept notes on all the birds and the action....

I: I think we will postulate that these notes do confirm that what observations you have made on the conditions of illness were of this general type characteristic of what they call the organic phosphates, which includes a large group of chemicals which are used for different kinds of testing.

S: Then I'd put the birds aside for a minute and get some insects and examine the insects to see how much of this chemical they have in them and if it is a large enough amount to hurt the bird if a bird eats it.

I: You'd have these insects analyzed?

S: Yes.

I: These insects would show...these are live insects or dead insects?

S: Live insects.

I: They are not ones that have already died from it? You collect some live insects from these fields and they show a trace or a fairly detectable amount of parathion...

S: If a bird with a large appetite eats quite a few of these insects then he'll have all the amount of parathion in it from all the insects added together--right? Or...

I: The birds have been eating insects that didn't die.

S: Yeah, but, it could show another thing that the Jackson County bird, since it has been eating these insects with this chemical in it, this parathion, it could show that the parathion could cause some permanent damage on the bird's tissue which is undetectable and that's why the Wyandotte County bird didn't die.

I: That bird had accumulated some effects on it before you brought it into captivity. Yes, this is a very good possibility. Now do you think you could be conclusive about a feeding test though if you proceed in this manner with insects which are alive and show only a trace of parathion? In other words, you don't really know much about these insects yet.

S: I have to make some kinds of tests on these insects and set up a control. Then when some of those healthy birds...

I: Where the healthy insects show no trace of parathion, it would be a very good test of whether this type of food could be bothering the birds. If they ate a lot of insects within a few days or a week it could accumulate. Is there anything further you could do in the way of a feeding test with insects to strengthen the answer to this question?

S: I'd have to get some healthy insects without any trace of parathion in them, the same kind that I used to feed the regular birds with.

I: This is a good possibility. I might mention that when a field is treated for pest control, some insects may survive, but they will be a very small number. Normally, they want to kill 90-99 per cent of the insects. And usually after a spray program the insects present will be mostly dead or sick insects for just a few days and they quickly disappear. This is the kind of information that you would find from your field observation in the area or from reading or talking to pest control people.

S: Do insects migrate?

I: Normally, the birds are the ones who migrate rather than the insects. They may be attracted into the area. You watch the birds flocking into these fields and feeding on these insects that are flopping down to the ground and dying from the spray, but that was not the kind of insects you postulated to me when you said you were feeding them. You gathered healthy insects that had only a trace of insecticide, so I presume that you got these from the border of the field or from an area that did not have too much exposure.

S: Since there are no insects in the middle of the field -

I: By the time you get there they have all been killed off.

S: Then I'd have to get some healthy insects and set up my own field of grass and put these insects in there and find out about how much of this chemical the farmer sprayed on the field and spray it on the field.

I: The spray [illegible]rator says, "Yes, I'll be glad to fly a few flights over your field [illegible]d spray your penned insects." So he does this and you observe it [illegible] your insects start getting sick and start to die, how would you p[illegible]eed from here?

S: I'd get the [illegible]nsects on the outskirts of my field that have just a trace of parathio[illegible] in it and feed it to my birds.

I: What would be the reason for picking the insects on the outskirts of your field?

S: Since all the insects in the middle are either dead or they're sick.

I: Okay, I really should give you some more data because in the course of doing this you are going to be quite interested in everything that happens. You're going to watch this operation and in the course of this you see birds flying into the field. After the plane has passed over and the spray is settling down, the birds are coming into the area and they are flying not only into the center of the field there, they're even flying into the area that was sprayed. They are feeding on this crop and your penned insects are starting to die. Birds are trying to get into the pens to feed on your insects and they also are feeding on the insects that are outside. They are feeding on the ones that are dying or have died. They come down and pick up some of the dead insects off the ground.

S: I have pretty good evidence then that could be a cause...

I: Look, can you strengthen this by your experimental...

S: Well, I have to get some of these insects that have died and check on a few of them how much of the chemical is in them. Then feed them to...

I: Have some of them analyzed by the chemist and you're also feeding some of them to the penned birds?

S: Can I have a constant supply of these insects or just when they come?

I: You can have a constant supply of them. We'll provide whatever you think you need.

S: How long would one of these birds take, these meadowlarks. how long do they take from when they're young to maturity?

I: They grow up in a period of about three weeks.

S: Well, this would be easy, because I'd get some young birds. I'd try to get them from the same nest and say four birds in a nest. I'd divide it up in half--put two birds in one part and two birds in another part--feed two of these birds insects that have either traces of parathion in them or a little bit of parathion in them and they're alive and these other birds I'd feed healthy insects.

I: In other words, you'd get some insects off the edge of your field like you mentioned that just have a trace of parathion and then you'd get some that showed in the analysis--but you can't analyze the same insects--you can simply gather some that are dead and analyze a part of them. You separate them and you analyze them and these show a higher amount, maybe two parts per million and you feed those to the other two birds.

I: Now what do you want to know about those birds?

S: What I'd like to do is get the two birds that are healthy and that I fed healthy insects to; they are my control so if anything happens to them that happened to these birds, I'll know the results and I'll know exactly what's happening where. These two birds that I fed these bad insects to, I'd divide these in half and put one bird in one cage and another in another cage and I'd start feeding one bird healthy insects, I'd feed both birds healthy insects and then after a period of time I'd feed one of the birds the sick and chemicalled insects and see what happened then, because this would show, if this bird were to die, it would show that this parathion has some kind of effect on the tissue of the bird.

I: Shall we give the results of this test? The birds that have been fed the dead insects get sick and showed tremors and the birds fed on apparently healthy insects survive.

S: Can I make a little drawing here?

I: Sure, go right ahead.

S. Here I have a nest, I have two nests, each nest having two birds in them. These will be the healthy control birds and these are fed insects that I buy from some science supply house which I know are healthy. Okay, then I divide these up into two parts and for a time feed both these birds healthy insects.

I: We'll say they don't die as long as they're on healthy feed.

S: Then I'd start feeding this one some bad insects, some insects that have been infected. If this bird does die then I know this parathion has some kind of long-lasting effect on it.

I: Okay, what about this one? That one is on insects that were taken from the edge of the field?

S. No, this one is fed healthy insects like these.

I: Oh, this is healthy insects from a different area. I thought this ate insects from...

S: He did, when he was young. He did in his earlier life. These have been fed healthy insects and these have been fed what do you call it, diseased, or what?

I: This has got some of the sick insects in it, but it wasn't artificially fed dead insects?

S: No. Both of these were fed sick and both of them had a percentage of chemical in them. After a time, I'd keep feeding them good insects after...

I: They're still alive up to the time you start feeding them dead insects.

S: I feed this one healthy insects for control. I feed this one sick insects and if he dies then I know that the chemical has a lasting effect on the tissue of the bird because the other one fed healthy insects stays alive.

I: Okay. Are there any other questions that you would ask or do you feel pretty well satisfied now?

S: Well, I'd have to check this thing out afterward because it could have just so happened that my tests were just happening on a few birds so I would have to get all of the other birds listed in my table and do the same thing.

I: In other words, meadowlarks, you've gotten some useful evidence on, but you don't know about the robins, cardinals, and others?

S: I'd have to make the same experiment on those birds, too.

I: Suppose we stick with the insect eaters. The results of this would be essentially the same. Could you state for me what you have learned to this point in time from this?

S: That the chemical causes some kind of lasting effect on the bird because when the bird has been fed up to a certain time with these sick insects and then stopped for awhile and fed healthy insects and then when they've been put back on this diet of sick insects, they die. So it must show that it has some kind of lasting effect, these bad insects.

I: Okay, fine. Now we originally started out with a question about why there has been increased mortality of birds in Jackson County and what you have learned, if I understand you, is that birds who eat contaminated insects over a period of time tend to die earlier. Are you satisfied?

S: I'd have to check to see how long the farmers have been using this parathion. Because if they have been using it for 50 years and the mortality rate has just been recent, then this is all bad and I'd have to check on something else, but if I found out that the farmers have been using the parathion just recently, just about the time that the birds started disappearing, then I'd know that my results could be good.

I: How do you suppose you could find out about the use?

S: I'd contact the Department of Agriculture for one thing and ask them how long it has been used in this area. Then I'd contact chemical supply houses for farmers and see how long they've been selling it to farmers in this area.

I: They'd refer you probably to the County Extension Agent who has quite a knowledge of this and he could tell you who the local distributors are for the chemicals and he could tell you "Yes, we've been recommending the use of parathion for probably ten years, but we're not sure it's been used in this county for ten years." He'd go again to the supply house and they'd say, "Yes, we stock parathion and we've kept it in this county. We've had it for ten years, but we haven't had very much call for parathion until the last year or two. Well, they tell us that the use of parathion for certain pests have been increasing and we've sold three times as much parathion in the last summer than we did ten years ago. It's been increasing because the pest problem is getting worse."

S: So you're saying that...

I: There's been an increase in the use of parathion in the past ten year period, so that what's being used now is three times what was being used ten years ago.

S: So I'll have to check to see if the birds ten years ago were dying off at one-third the rate they're dying off now.

I: That's pretty hard to get that information. We'll find out that probably nobody ever studied birds in Jackson County ten years ago. But let's say that you inquired of this at the university and they say, "Oh, we had a graduate student doing a master's thesis problem on bird abundance out there ten years ago." So you look up his thesis and he will have some census figures. He ran nesting counts and located the number of pairs of nests per acre. He gives you what these figures are, five pairs of birds nesting per acre over a sizable area and he also ran what we call trend counts. That is, you follow a walking route through the fields and down the country roads and you walk about four miles in two hours in the early morning. He counted an average of 25 birds per hour. That's approximate activity or abundance of birds that was seen in the area ten years ago and the number of pairs of breeding birds that he found. He would also have some data on the kinds of birds that were there and the number of young in the nest and this sort of thing. It's quite a bit of information on general bird population available ten years ago. What would you tell from this?

S. I'd have to check what the bird population is now. And see if it had decreased. I'd have to make up another table, a mathematical table and make a ratio and see if there's a ratio between the number of chemicals used and the number of birds that died.

I: How would you compare your bird populations, how would you get this for the present period?

S: I'd have to find someone who goes around counting birds.

I: There's nobody doing that. You'll have to do that yourself. Although we did postulate that there was some evidence of increasing mortalities so we would have some evidence. We can proceed along this and assume that whatever is necessary gets done either by yourself or somebody else. The evidence, by the same procedures, is that there has been a decline and that the number of birds is actually much less than one-third. Instead of 25 birds per hour, you only see four and one-half birds per hour and nesting birds are only about a tenth as many.

S: Well, then I'd have to account for a lot of other problems. The main one would be that I'd have to check on the migration habits of the birds and how much this parathion has been used and in what place and then see if that would make any difference.

I: Now, I think you can probably see at this stage another thing in the way of general plan that might be pointed out. When one gets into testing various hypotheses one is dealing with so many variables and difficulties of keeping birds alive. We know that every bird has a short life span. Some of the birds will die anyhow, due to unknown or uncontrolled factors. You're in real trouble if you use only one bird and your healthy control bird dies on you. Because it is possible for a control bird to die from unknown causes or from old age. It wouldn't be a nestling dying from old age but perhaps minor accidents. In the course of testing, it is always good to start out with a group or with several numbers of individuals that are being treated in parallel. Then if something goes wrong--and it's a good plan to assume that something will go wrong and some of your birds won't survive--you will still have some additional ones that you can use. You can simply set this up very similarly and say that we used five pairs of nestlings.

S: Now as I think of that, we could have used five...we could have had ten pairs of nestlings each divided up into two separate five groups so that you would have five like this and five like this. You say these take three weeks to maturity. We would have unlimited time, see. So, what I think would be the best thing to do is try to make sure that all these birds have the same type of ancestry because then you don't have the situation that one bird might have not enough antibodies to resist something.

I: Were there points in our discussion when you would have liked some kind of help that didn't occur to you then, but occurred to you later?

S: One point, I can't remember exactly what we were talking about now, but about a couple of minutes later I thought I should have asked a different question. I can't remember what it was right now.

I: Was that because of the response that we gave?

S: No, it was because of a question that came to my mind a little later that I should have asked.

I: If you were to start this all over again, would you take a different tack or pretty much the one that you did?

S: I'd probably start out with what I was doing now, but I'd probably try a different one just to see what the results would be and probably if I had a chance to compare the two and see.

I: Is that decision now to pursue different ideas a result of knowing what you did or do you think you would have been better off to have done it in a different way and not pursued the way we did it?

S: I think that there is more than one way of doing it and I think that since I did it this way I could try another way and I'd probably get some good stuff.

I: I might make a comment in this regard to fit the situation. For the most part I think you did very well in pursuing the search for evidence and answers in the field and at the same time pursuing by laboratory experiments in such a way that they complement each other or help to answer the question. I was encouraging you to do this to realize that sometimes an answer can better be pursued in one way than another but I never did get clear in my mind why you chose nestlings to experiment with rather than adult birds. The reason that I say this is that nestlings are harder to keep and there is only a three-week period you see. Now, is there any reason why you didn't want to use adult birds? We didn't say which of these dead birds were out in the field? As a matter of fact, I visualized them as adults.

S: That's the reason why. Because I figure if I get nestlings, nestlings are just born, you see we incubated the eggs outselves and it has nothing to do with the outer environment. They are just clean birds, real nice, and they don't have any chemicals in them.

I: I see. They could have come from the same area, but they wouldn't have been exposed if they were just incubated. This is one way to do it. Another alternative way would have been to go to Wyandotte County and get birds from there to use for your experiment. You might have gotten adult birds this way. I am not saying there is anything wrong about this, but in terms of the difficulty of doing it... Also, this would have been especially pertinent if your observations in the area had shown you that birds were dying in the nest. We did not bring this out. But if the birds dying in the nest were a cause for concern, one could learn something by searching for nests and examining the contents. We did say that we learned there was a lower survival of nestlings from this survey that the master's student or somebody did in the area. Nothing specific was said about that survival.

S: That was where that table I was thinking about in the beginning would come in.

Interview Number 2

S. The first question that comes to my mind is: Has there been a virus or a disease in effect about this time, and are these dead birds of any particular species or several species?

I: You've asked several questions; which one would you like to follow first?

S: Are they of one or several species?

I: How would you go about finding that out? Where would you go to get that information?

S: Probably out into the field itself. I suppose just observing, or trying to find diseased or dead birds.

I: Suppose this is Jackson County, and you know Jackson County reasonably well. What kinds of places would you go?

S: Maybe, possibly during the spring or summer, you could go to Swope Park, but I think you might.... Is it all right to investigate the outskirts of Jackson County itself, possibly in the areas of Lake Jacomo or the outlying districts of Jackson County? Maybe you could find more information about the migrations of this particular species.

I: Now you have collected several of these birds. You would presumably find that there are several species involved. You might have cardinals, some blackbirds, some robins; and you are able to have these identified. Some of these are dead; there are also live birds out there. What would you do next to try to find out whether disease was involved?

S. I suppose you could take it to the laboratory and find out if a virus is spreading, or possibly you might try to investigate the fact that another species is crowding out these other species by limiting their food and water supply. Maybe you might want to observe these birds during their nesting or feeding periods.

I: In doing this, how would you determine whether or not other species were involved? What kind of information would you want to gather? First of all, maybe we should eliminate that. You have asked for information on the viruses. Say in the laboratory reports we have taken cultures of the tissues of these birds and we find no evidence of virus disease or of other bacteriological disease. There still might remain other possibilities, including the one you suggested and perhaps others.

S: Did you say that there were proper food conditions?

I: Yes, the food conditions remain about the same as they have been in preceding years when a normal abundance of these birds were present. Now, your hypothesis is certainly a good one, that there might have been other

birds that have moved into the area and that have competed with these birds or killed them. Now how would we go about finding this out?

S: I imagine I would have to go out in the field and just observe and dig from my observations to try to form another hypothesis that would be more complete.

I: Okay. You are out in the field and you are observing these birds. You determine what kinds are present and to your knowledge you haven't recognized any new species that were not there before on the basis of what people could tell you about birds of the Jackson County region. Would you carry this any further? Could you determine this entirely in Jackson County, or would you want to look in other places?

S: Well, I would probably like to look into the environmental conditions. Since Jackson County has industry, possibly there might be pollution involved, because throughout the years Jackson County has changed, and maybe this has affected the birds somewhat.

I: Okay, we don't see any evidence of any new kinds of birds causing damage. The kinds of birds you have found present are the ones that have been there years before. They are the same species of birds that are present in the adjoining counties. There isn't any indication that birds have suddenly flocked into Jackson County and deprived them of their food, but it is possible that the environment has changed. What would you ask next and what field information or laboratory information would you want on the dead birds or on the environment that might give you some further clues?

S: Well....

I: You mentioned pollution as a possibility.

S: Right. Maybe I would try to find how it had affected the air itself or the food or water supply.

I: How do you think you might go about getting this information?

S: Probably I would have to take specimens and just go to the laboratory and do experiments. I would have to find it out for myself.

I: Where would you go about getting these specimens?

S: Well, previously you had talked about their nesting and usual eating locations, so if I were out in the field and had access to these feeding and nesting locations, I could take specimens there in the field.

I: And you would get some of the live birds that were in the area. You'd get permits to get them and have them analyzed, or examine them yourself or whatever you wanted to do. What particular details would you want to know about them?

S: The thing that crosses my mind, if I were to take some of these wild birds and put them in a controlled environment of my own, if I were to capture them, maybe I could find out if they would succeed in a man-made environment.

I: When you say a man-made environment, what do you have in mind?

S: I suppose it would be more or less caging them in a.... I don't know exactly how you'd go about it, but somehow set these birds aside and have several groups of them and make observations on them and see if they...I don't know exactly how my environment would differ from my regular environment. I don't know whether to include any differences or to have them exactly the same.

I: What kinds of questions would you be asking? Are you thinking of exploring in relation to pollution or contamination with chemicals of one kind or another, or are you thinking of exploring the possible effect of changing temperatures, things like this? If you have a particular aspect of the environment in mind that you want to test, then we can tell better how to go about with this test.

S: Well, I don't think temperature change would make that much difference. Probably the most ideal thing to do to provide experiments on the contamination part.

I: There are a number of possible things that might be involved: air pollution; drinking water; different kinds of chemical poisons like herbicides or insecticides. You'd have to have something a little more specific in mind as to which of these possibilities would be most likely. How would you decide what things you want to test for or expose birds to?

S: I think if there were any pollution or contamination it would be where they acquire their water. Since these are wild birds they'd have to find their water out in the field, and since there are so many polluted creeks in the greater Kansas City area, it would be my first hypothesis to think that the water would be responsible for this.

I: Okay, how would you go about determining whether the water was, in fact, polluted? In other words, if you want to test your exposed environment, you need to know something about what conditions you are going to put into this environment to make it resemble what was in the Jackson County water.

S: Well, I know one thing: I'd have to provide contaminated water.

I: Maybe a lot of the birds are attracted to a certain pond where they come and drink. You expect that may be what is killing them. Is there anything you can do to pin down this and identify it?

S: Well....

I: Don't forget, you have laboratory facilities available; there is the library, or any kind of specialists you need.

S: Well, I was wondering if any change took place in the pond or waterhole that would change it. Water itself would change if it was in a completely wild area....

I: This is quite possible. Would you make any inquiries in the neighborhood? What else would you do? Suppose you had to sample this water?

S: Well, possibly....

I: Let me suggest, in the course of your field investigation you talk to some of the local people. Maybe the farmer who owns that pond has come out to ask what you are doing, why you are interested in the birds. Do you think he could throw any light on this for you?

S: Well, I suppose he would have an idea whether any change took place in the pond, whether....

I: He's probably been living there ten years or so, perhaps, cultivating fields and what not. What kinds of questions do you think you might put to that farmer?

S: Have you had any people dumping refuse or garbage into your pond? Like I know of a creek that used to be a pretty good creek running by this farmer's house and over the years people have been dumping their garbage in it, and now it cannot support any fish or anything.

I: This is a possibility. Well, the farmer says, "No, I don't let any dumping go on here, but my neighbor over here has hired this spray pilot who comes out and sprays the area, and I did complain about this because the spray company came over and washed out all their containers in my pond."

S: Then again you would have another aspect of the outside environment.

I: That's right. You don't know yet whether it could have killed birds. You have another clue. What would you do then?

S: Well, you said that possibly someone has been spraying.

I: Somebody has been spraying in the area to control insect pests. They used these drums and tanks of chemicals. When they are through, of course, they have some leftover materials, or they have to wash out their equipment. Sometimes they will go to a pond or stream and wash it there. I'm not saying this is a good practice, but this is what the farmer observed.

S: You learned this much? So then you would probably suppose there are foreign chemicals and elements that would be harmful to the birds, but then again when you brought out the point that they used this to be killing pests and insects, couldn't that affect the food supply itself of the birds?

I: It certainly could.

I: Supposing now that you wanted to pursue that. Would you pursue that with the farmer, or how would you try to go about working on that?

S: I don't think the farmer could help me anymore. I would perform a laboratory analysis of the water.

I: Okay. Good. A chemical analysis of this material, is that what you'd ask the chemist for? To tell you what was present?

S: Right.

I: All right. The chemist reports that the water contains two parts per million of dieldrin, which is an insecticide. It's a very persistent chemical and it's used for many agricultural crops. For instance, corn root worm might be killed by it. Now that you have this information, what would be your next step?

S: Well, you would probably merely observe the birds as they.... You might want to set these birds aside, observe the birds and watch them as they drink from this waterhole. If there is some way you could tag or watch certain birds that had been drinking from this water.

I: How would you go about tagging these birds? Suppose you want to do this, and you read up a little bit on this. There are common methods used; you can capture the birds and put bands on their legs. You release them and see what they do, and anytime you catch that bird again you can identify it by the number on the legband. Another thing you can use are various tracer materials that can be put in the water like radio isotopes and could be identifiable with that water wherever it goes. What type of a procedure do you think would be suitable here?

S: I would prefer the legband. I think if you use regular isotopes you don't know but what they might affect the birds themselves.

I: What sorts of things would you be looking for?

S: I would, of course, see if they had been drinking from this polluted water. I would try to see how this polluted water, if in any way, affected them after they had drunk from it.

I: Now you've observed this. You've spent a morning out there watching the birds. You see some come and they drink at the pond. What would you do then? What particular things would you want to find out about them?

S: You might want to observe them with the rest of the community.

I: Yes, there are quite a few birds. Not all of them drink at the pond.

S: You might want to see if they differ from the community in any way, or if they associate or isolate themselves from the community after drinking from this contaminated water.

I: Perhaps some of these birds show symptoms of illness. They may have poor coordination; they can't fly very well; they wobble when they come down; they can't land without falling over, and pretty soon some of the birds die.

S: Then I suppose you know for a fact that this outside water pollution had some effect on the birds. But maybe you want to take these dead birds to the laboratory and perform an autopsy to see if you could find out whether this foreign chemical element was present in the body at the time of death.

I: So you take it to the laboratory; you ask for an autopsy and for a chemical analysis. You get a report that says: This bird had a broken neck and it also had residues of dieldrin in it, one-half part per million; and two other birds had residues, two parts per million and one part per million.

S: Since you brought up that part about the broken neck, either of two things could have happened: either it died as a result of the broken neck, or as you said before, the contaminated water had affected its coordination and made it more susceptible to accident, you know, and died as an indirect result.

I: You probably have some good clues there. If there's good evidence of an accidental death, then it's a matter of interpretation whether you want to lay any of the blame on the dieldrin. But you do have some birds now who don't seem to have any evidence of injury; nevertheless, they do have the insecticide residues in their tissues. Is there anything further now you'd want to do?

S: You might possibly want to see how much of this insecticide, the various amounts in what ways it would affect it. Like, say, you might have so much contaminated chemical element present in one bird and so much in another....

I: It varies in different birds, yes.

S: From observing the various birds, from their containing this various element, see how it affects them at the various stages.

I: How would you go about doing that? Don't forget, you still have other birds in the area. We haven't killed all of them. There are still live birds flying around.

S: Oh, I see.

I: These birds may have drunk water out of the pond, but they haven't died yet. If I understand your question it is something like this, "What is the effect of different amounts of pesticides on wild birds?"

S: Right.

I: You've learned you have some residue pesticides. This dieldrin you've measured is present in the water. It has been present in some of the dead birds.

S: Well, you would see how much is present in the dead birds and how much is present in the ill or affected birds. And I don't know how you would actually find out.

I: How about the live birds that don't seem to be ill?

S: It seems like we have sort of separated them, but I suppose it would be wise to see if they had any of this chemical element in them, because due to a much lesser amount or something of that sort, they might not be affected.

I: How would you go about determining or answering this question about the live birds as well as the sick ones?

S: You will probably want to step up the amount of the chemical and observe how more and more amounts of this element would affect them, or several birds.

I: Would you want to have the same information about the live birds and the sick birds that you had about the dead birds? You know the dead birds have some dieldrin in their tissues. We don't know what's in the tissues of the live and sick birds.

S: Well, I suppose you could always find out if you had a chemical analysis in a laboratory.

I: Okay, that's the point. Would you want chemical analyses also of these others?

S: Definitely.

I: Okay. We get specimens and send them into the laboratory. They report that the sick birds have residues, too, and they vary from one-half part per million to two or three parts per million--essentially the same as the dead birds. The ones that aren't sick have a lesser amount. Some of them don't have any, some have a trace of dieldrin, and some have a small amount, maybe only a half part per million. Picture your distribution: dead, sick, live. The amount of dieldrin present is fairly similar in these, but down here we have birds that may have a little bit, and some don't have any at all.

S. I think that pretty well answers the question. I don't think we need to bring out any other outside environment. We know that this contaminated water is responsible. Perhaps we would like to go further in our experimentation because we pretty.... From the results of our experiments we pretty well know that this is responsible.

I: Okay, now supposing that you've conducted the investigation pretty much the way you have, and now you're thinking back over it. What would you do differently if you were to start over? Or would you do it any differently?

S: I might try to bring in another aspect of the environment such as nesting or feeding conditions, but that would be pretty hard to do since you said that over the years they have remained pretty stable.

I: You see you do have a degree of uncertainty because some of these live and apparently unaffected birds had a half a part per million of DDT, and some of the dead birds had half a part per million of DDT. I think you reinforced your interpretation that you are on the right track, but you might think of other things you could do to strengthen your case. Some pest control operator or chemist might say, "Well, you really haven't proved anything; we don't think that caused it. It might be something else." Maybe they say some of this is coincidence. Or the farmer who feels he needs to use that particular pesticide would say, "Well, I don't think that that really does have much to do with what's causing it." Now what would the farmer or the pesticide manufacturer come up with as alternative arguments to say that it probably isn't the pesticide? They would say, "We have been concerned about these residues because we know they're very persistent. They are found in the waters and in the environment, and for that matter it isn't enough to be harmful." They would present some data to show that some laboratory animals have been fed this material and had as much as one part per million. White rats have been fed this and lived. Rats sometimes have died at higher levels. Birds like poultry or pigeons have been tested and had small amounts of dieldrin. If you get enough dieldrin it would kill them, but just the presence of residue alone doesn't prove anything. Furthermore, you find out that the residue is usually concentrated in the fat. If the animal is a fat animal, it can contain quite a bit of residue and apparently won't die. However, you also find that if it is in the brain it takes much less to kill the animal.

It's a complicated picture. Usually the brain is the best argument to use. You wouldn't be expected to know this in your initial investigation, but this is one of the things you could look into, analyzing the brains of these birds rather than the whole body or the fat. Furthermore, you find that these chemical companies tell you they have taken great pains to insure the safety of this material by testing it on white rats, chickens, and poultry. The question you might immediately ask is, "Have you tested it on any songbirds?" They say, "No, we don't know how much it takes to kill robins or meadowlarks."

S: You're getting to different body systems, and I think I should have studied more about this particular wild species of bird: its chemical makeup, its structure, its function.

I: If you were given the means to do this now, is there something particular you could do by testing the effect of this on live birds in captivity, or is there another way you could compare this with the information the chemical company could give you on white rats?

S: Well, white rats might not be as susceptible.

I: In fact, the data indicates you would have to have five to ten parts per million in the tissue, and you might have to feed a good deal more than one or two parts per million before it would kill them.

S: You are limiting it to one species and that effect and they are not concerned with anything else.

I: So what would you ask the chemical company about their data then? Would you get together any more information from them? Would that help you with your birds, or would you go out and get that from your own investigation or experimentation? You have countered the argument to them that the data on white rats is not valid for birds. The rat is not a bird and perhaps the chemical works differently on birds. They say, "Well, we don't have any information on songbirds." Do you have any information to show that dieldrin is poisonous to songbirds?

S: Assuming that was the species we were working with, yes.

I: You do have some songbirds. You have meadowlarks, and you have mockingbirds.

S: In other words, I would show them the results of my experiments and see how they would try to counter. Maybe once they tried to counter with a certain argument I might try to improve my hypothesis.

I: Okay. Where do we stand? We have the amount of chemical present in the bodies of these birds that were out feeding at the pond. We don't have anything on the captive birds yet. At least if I am correct in recalling, we didn't pursue that very far. You did talk about manipulating the environment to find out if pollution or something was involved and doing it with ten birds. And then we went over the field situation to find out what it is in the environment. We didn't know what to manipulate in the cage. Okay, we found out there was chemical in the water. We have this clue now--a very strong clue--that it is dieldrin. But we haven't conducted that pen test yet.

S: So you might want to have the same thing--contaminated water--in the pen environment to see if that affected them. It possibly might not affect them as much.

I: How would you set up this test? What would you do? How much chemical would you put? Would you put it in the food, or in the water?

S: To make it with the field situation, I would imagine you would try to simulate your field conditions as best as possible in the pen environment.

I: Okay. We know that in the field condition that we had up to two parts per million. Okay, we have a range from one half to two parts per million in the water in the pond, so this is what you are trying to approximate.

This can be done. The chemical company can tell you. They are pharmacologists, they know how they conduct tests. They can tell you how to formulate this material to get it into the water. You might have to use an emulsifier and see. You can go on and do this and put them on a test for a period of time. What would you do about this? I guess we have to have some results here, don't we? What is the question you would like to have answered now?

S: What is the main difference between a pen environment and an outside environment?

I: Okay. We have a supply of birds available in a number of cages and a water supply with the pesticide in it. We can mix it with whatever dose rates you want. Can you say anything more specifically about how many birds you would use, how many different cage tests, what birds drink the water, or do you have any thoughts as to different ways this might be done that would give you a stronger argument or a more conclusive result? Would you put all the birds in the same cage and expose them all to the same water or would you put them up into different groups, or would you put any of the birds in a cage test without the chemical for instance? There are different possibilities.

S: I think you should vary. What does the vegetation have to do with it when it affects this pond? Does the vegetation...more of the outside environment you couldn't provide in a penned-up cage.

I: This is true. Your pen is going to be a little bit of an artifical situation in many ways. The feed will be a degreee of artifical food like poultry food or something. The water may be more similar to the wild source of water in the pond. One has to make certain of the artifical assumptions in making a test, and you can only vary certain things in the test as you go along. If you change many of these things then you get your results all confused. You have to decide whether you want to change several of these variables at once or whether you want to keep the test fairly simple and uniform and test just one thing at a time. I'd like to stop your investigation now and talk a little bit about how we have been working at this. I'd be interested in any comments you have about how we've tried to work here this morning and where you had the biggest problems and what you would like us to have done differently and whatever.

S: I think that maybe I should have formed a better chronological order as far as my hypothesis and my experiments were concerned. Because I'm still a little mixed up on just what to and what not to include in my environment, you know. Like you brought up the point that they're using this pesticide to cut off insects and pests, were these the same insects and pests that these birds were feeding on?

I: That is a very good question. Lots of things could be causing it. We pursued one possible explanation, and as I am sure you are aware of, it's possible that the mechanism by which the birds get the pesticides could

come from other means. These residues could have come from something besides the water. They could have come from the insect food, they could have been feeding on the pests that were killed. This is a possibility. You did bring out some supportive evidence which strongly pointed toward dieldrin as being the cause. The feeding test that we were in the process of setting up could have shown you whether, in fact, it was possible for birds to have been killed by the dieldrin in the water. Even that wouldn't necessarily have been conclusive. It's possible that those birds did get some from the water. It's possible they also got them from flying across the fence and feeding in the field that was treated. These are perhaps minor details, but at least you have pursued it far enough to throw a very strong finger of suspicion on the insecticide as being the cause. One thing I think that we were interested in as to the feeding test is to try to pin down the amount. The feeding test might have shown you what amount of dieldrin could have killed meadowlarks as say compared with the white rat. You might have found that it took more or it took less. Under the conditions of the pen test which of course aren't the same as the field, they are artificial. But still, if they were standardized like the chemical company pharamacologist's, you could compare your test with his and say, "See, this shows that meadowlarks are not the same as white rats." That was one line of thinking that we went into. Was this what you had in mind in connection with the artificial test to counter the chemical company's data?

S: Well, yeah, we brought out that whatever species you might bring in might be completely different as far as being susceptible to this.

Interview Number 3

I: We want you to keep in mind that you've got the kinds of resources that a good library or a good laboratory would make available to you and we'd like you to start saying, "Well, now how shall I go about finding out something about this?" And talk out loud as you do it.

S: Well, I'd kind of like to know anyway because I don't know if it has anything to do with a bird or not, but I had a rabbit and it was a wild rabbit and I don't know what happened, but we brought some more in and all of a sudden they all died and I just wondered if maybe that one had some connection, I don't know.

I: That's the kind of problem that can arise. You're pointing to the fact that the problem that is posed on here is a real problem, it is not a pretend problem in the sense that this kind of thing is happening in many kinds of places. Why don't you go ahead and pursue this?

S: I'm supposed to be trying to find out what happened to them, right?

I: Yes, what do you think you would like to do first?

S: Where...this is just all over in Jackson County, or was it in the woods?

I: It was in Jackson County. What kinds of places would you anticipate that you wanted to look or get the information about?

S: Well, I'd have to think where would birds be? Where do they live in the first place? It depends on what kind of wild birds, I guess. Where do they live?

I: Yes, there are many different kinds of wild birds in Jackson County and they live in almost all kinds of habitats. Some live in farm fields, some in wood lots, some around ponds and streams and so on.

S: They don't know what kind of disease or anything they've got?

I: This is for you to pursue.

S: Well, I'd have to find out about all the diseases of birds, but that would take forever. What kind of diseases they could....

I: Let me see if I can help you phrase your question. You're saying, "What kind of diseases do birds have in Jackson County?"

S: That's it, but isn't that too broad to answer?

I: A broad question like that needs to go to a library rather than a field investigation and the library would give us literature that would tell us that there are a number of diseases that birds might have that very little is known about them, but one of these is fowl cholera. It's a disease of poultry and also of some wild birds. I'm no authority on this, but it might be present in Jackson County. I don't know of any reports of it being there. What would you like to know next?

S: It said that their food supply and nesting conditions were reasonably good. Their food supply was adequate. Does that mean it was adequate for all of the birds?

I: For the population. In other words, he sees no reason why we couldn't have a normal population. There is no real food shortage. This is meant to be a clue to help you.

S: Well, if you don't know about the disease it must be something in the environment like....

I: Let me ask, did you find out everything you wanted to know about the disease conditions? Because I think that the question I understood you asking was, "What kinds of diseases can birds have?" And the answer the library gave you was that there is principally one kind of disease that we are aware of that birds can have. That isn't the only one though. I could name a few others...batulism, but this is a disease mainly of water fowl and it's called "duck sickness" for that reason. There are others.

S: This is just all birds in general, though?

I: We don't know yet what kinds of birds these are.

S: I can't just ask a library....

I: We will invent certain answers that are reasonable.

S: Can I ask whether they are water birds? Or not that kind of a question?

I: You can, but how would you go about finding out?

S: Where are they being found? Is it around water?

I: The library would tell you that water birds live around ponds or rivers and they are present in all parts of the State. Now whether or not they are present in Jackson County yet it doesn't say.

S: Right.

I: How could you find out about Jackson County since that is the one you are interested in?

S: I'd have to find out where the areas of water are around here.

I: Have you been in Jackson County?

S: I don't know what they are though, let's see.

I: What what are?

S: What the water areas are--Jacomo is one of them isn't it? Oh, great.

I: You said you wanted to know what "they" were. Is there a particular "they" you are wondering about?

S: I meant what kind of bird. I think that's what I was thinking about.

I: What kind of birds do live in Jackson County?

S: Well, what kind of birds this would be.

I: The dead birds, you mean? So the question you are asking is, "What kinds of birds have they found that are dead?

S: I can't figure out how to find out.

I: How do you suppose you could find out what kind of birds are dead? What are these dying birds?

S: I'd have to find out where they were found first, I imagine, to find out what kind of birds they were. I'd have to know where they were found, like Jacomo, around water, in farmer's fields, or what.

I: Where would you go to find this out? I need to know whether I'm answering as a librarian or as a chemical laboratory, or what?

S: All right, I'm out in the field.

I: You go out to find out and observe yourself. I would say then that we don't find any water birds that have died. No one has picked up any ducks, but the kinds of birds that have been picked up have been birds from the fields and woods. They have been meadowlarks, bluejays, robins, mostly songbirds of several different kinds.

S: Is this a farmer's field where he raises crops and maybe uses something to put on his crops--insecticides?

I: Some of them have been around farmyards, around fields, some of them on roadsides, different places, but farm fields have been included.

S: Have the farmers around this area been using insecticides and different kinds of things to put on their crops?

I: Yes. The farmers in that area would tell you that they do use insecticides of different kinds at different times for certain pest problems.

S: Back to the library. Do these birds eat things like grains...like corn and things like that?

I: Yes. Some of the birds are seed eaters, grain eaters. Such as the cardinal and the sparrow, and some of them are primarily insect eaters and fruit eaters like the robin and the meadowlark so we have birds of two or three kinds.

S: If the insects ate the plants with the insecticide on it would that affect the birds if the birds ate the insects? At the library...

I: Yes indeed. This happens. We find in the book at the library about the effects of spray programs that in some cases the spray itself is highly toxic and will kill many birds in the area almost directly from contact. These are groups of insecticides which are often short-lived materials. They don't persist a long time. Also, there are many insecticides which will kill only indirectly as through the food. Some insecticides are what they call persistent--after they are sprayed they will gradually disintegrate or decompose over a period of months, but even the following two or three years there will still be a substantial amount present and these are particularly the ones that are often found in the food. That doesn't rule out that one of the short-lived, toxic materials might not be ingested in insect food. You can spray the field and kill the insects and the birds come in and eat them. They may either die from direct contact with the spray or the leaves on the bushes or they may eat the insects and die from

that which is very common and usually considered as a more typical way in which they are exposed. But we do have several kinds of insecticides in the two broad classes--the short-lived ones and the long, persistent ones. And the long, persistent ones become very much a problem because sometimes it has been reported in certain parts of the country that birds will die off nine months or a year after there has been no more use of it.

S: If I go to the agricultural department could I find out how often these farmers use insecticides, if it be every year?

I: Yes. The local extension agent has contact with the farmers and he knows what ones are currently being recommended. They recommend several different chemicals for different crop pests. A lot of these are used in Jackson County. Let me mention two kinds--parathion and dieldrin are being used quite a bit for different crops. Parathion is a short-lived material, highly toxic. Dieldrin is a persistent chemical used for different purposes. It's one of the kinds that may last for years. Now I might say this too, that the agricultural department will tell you that they are very concerned about the safe use of these insecticides and the health hazard to people and for that reason prescribe the dose rates that can be used. Farmers are not supposed to exceed these; and the pesticide applicators know how many pounds per acre is safe to put on a certain crop. You can be assured when that crop goes to market, whether it is beans or corn or whatever it might be, none of the chemical remains in the food. The agricultural department conducts experiments to find out how much chemical is needed to kill the pest and then they use a minimum amount required to kill the insect, say beet grubworm. They recommend this dose rate and before the farmer is authorized to use it they check this amount. They measure the beet and if none is present at the time it goes to market they tell the farmer, "Yes, you can use it. But don't use more than a certain amount because it will exceed the safe limit." So as long as the farmer is sticking to these prescribed rules he believes that he is safe as far as human health is concerned. He doesn't know necessarily whether it is killing birds or not, but for the most part the agricultural department tries to advise him to do it in the safest way possible. Here we are on shakier ground because we haven't advanced as far as we should be.

S: It said it just happens in the summer months so that would say...well, do they use this insecticide...I don't know whether that rules out spring and fall or not.

I: As far as the death of birds it was in the summer months. Now some of these pesticides are used at other times of the year but that is a detail that relates to the kind of crop insect. They usually apply them in the late spring or early summer. It depends when the pest is at its peak or most vulnerable to spray, when it is most necessary to protect the crop. Also, this is the breeding season for birds. They are normally nesting. It's a time of year when there is usually an abundance of food and we would expect to have good conditions for birds at this time. I think that the question we're pursuing was, "Did the farmers put the pesticide on

at a time that there was an increase in the bird mortality?" Yes. This is true. At least in the preceding season. This is normal so that they would have been putting pesticides on prior to the bird deaths.

S: Let me ask the same kind of point.

I: The death rate is not confined to a few days. It extends over two or three weeks or so. Neither does the insecticide use occur instantaneously. Different farmers may be spraying at different rates and within the early summer period.

S: Are the birds all found in one field? Would there be a whole bunch of dead birds where if you went to another field where they haven't used pesticide for awhile there wouldn't be so many dead birds?

I. This is something we would find out by going out into the field and...

S: That's a field test.

I: Are you doing this by your own observation or by interviewing people to find out what past history was? You do have some recourse. Birds have been dying and I'm wondering if this is information regarding that which has already occurred or are you going out to see it happen yourself?

S: Say I was going out to count the birds and I went around to ask...well, to count the birds...I don't know. I would ask...but, would there be more in this farmer's field than over here?

I: Let's put it this way--the past reports--the farmers that talk to you--you find out several of them have found dead birds. These have been called to the attention of the press, or the university, or other places, and it hasn't all been concentrated in one field. In different parts of the county but generally in agricultural areas. So you go out to look yourself. In that part of the county where more insecticide has been used, you are finding most of the dead birds. You search the fields and the roads and you have picked up a few dead birds in nonagricultural areas. If you go more distant you will find, oh, you may find a very few dead birds, but you won't find as many.

S: I think now is the time when I ask, "Where do we go from here?"

I: Why don't you summarize some of the information and let's try to think from that.

S: Well, I've found out that during the summer where the farmers have been using insecticide or pesticide...

I: Pesticide is a little broader. It includes weed killers, too. Insecticides kill only insects.

S: I think it is more or less insecticides. During the summer when they are using insecticides in this area where the birds have been found...wait a

minute, if this happened in the last ten years, if I go back to the agricultural deal I will find out whether insecticides have come into use more in the last ten years.

I: They have statistics on this and they do show an increase. Usually each year is an increase over preceding years and the use of these common insecticides like DDT, parathion, dieldrin, endrin, and so on is higher and has been higher in the past year than the preceding years. There has also been a change in emphasis and the kinds of use. Originally, DDT was the first one. It's been used about 25 years. In later years there has been a shift in the different kinds of chemicals in trying to find safer ones though more of the chemicals used in recent years have been shorter-lived ones that break down and don't persist in the soil or in the environment so much. But we do still have a variety of chemicals being used.

S: DDT was stronger?

I: DDT is not more toxic. It is less toxic than some of the others, but it is a very persistent one. Some of the others are very persistent.

I: What does persistent mean?

I: It lasts a long time. It is stable. It does not break down. The non-persistent kinds decompose within a few days or weeks at the most and they are harmless, you see, they are gone. But the persistent kinds remain in the food, whatever eats them then picks them up in their tissues in their body and if a hawk feeds on the bird it acquires the pesticide from the bird that it ate. It is transmitted from one to another. It persists. If it breaks down and decomposes, then there is no greater hazard to the bird community from the chemical. That's why there is a preference for the use of short-lived or unstable materials that decompose. They kill insects and after they have done that job you don't want them hanging around causing damage. So if they decompose this is the advantage. From the wildlife standpoint at least, it also makes it a little harder to kill the pest insects. It's nice to have some remaining around to kill a few more bugs. This is the reason they use the persistent ones in the first place. The chemical companies thought this was wonderful. You could spray your house with DDT and it kept on killing flies for two or three weeks. It took awhile to find out that you had accumulated so much DDT in your own body that in time, you see....so they are a little more cautious about it now.

S: It seemed like if DDT was persistent that...if that was before ten years ago...if they were using it before then that...

I: The use of DDT increased greatly and then it has tended to level off. It is still being used, but it is not increasing like the others. We don't have enough information yet on Jackson County that you can specifically say that this chemical killed these birds, have we?

S: Great. Well, let's see.

I: Even if it is the chemical at all.

S: It seemed to point that way.

I: Yes, you seem to have some clues all right.

S: If I go out and interview the farmers and ask each one of them what kind they use in a certain area, kind of like a...

I: You run into complexities. You don't even know if these birds stay here. You will find out from observing birds that they move back and forth. Some of these birds roost over here in this woods then fly a quarter of a mile over to a certain field to feed and then go back again at night.

S: These are all birds--I think when you named them off, the cardinal, bluejay, sparrow--that stay around in the winter too, so they wouldn't be migrating to get anything else to bring back, would they?

I: What's the question you are trying to ask?

S: I am trying to find some way to figure out which insecticide it would be then.

I: Do you think you have all the information you need about the insecticide? Maybe you need to get a little more background information on this insecticide. You were going to interview all the farmers or something like that?

S: I was going to see which insecticides they used. But I don't know whether that is possible or not. If I found out like in this area would that also deal with an area over here? I don't know what you call it, the percentage or something.

I: Comparing statistics of the amount of insecticide use, the local use, so much is used here. It is quite possible that with a lot of work you could draw even a map for 1968, 67, 66 and you'd have all these different fields. You'd know which crop was treated. We have done this, as a matter of fact, in forest pest programs on a large scale. We don't do it for cropland today. And you'd have a pattern of different fields that were sprayed--this one with parathion, this one with dieldrin, over the whole county. Maybe before you even got that finished you would do some thinking about how useful this is and where you would go from there. Let's suppose that you do have it. Then the information you want to know is: What kinds of chemicals are being used as pesticides? Was that essentially your question?

S: Which one might be effective in killing them off, which insecticide.

I: There are two principal ones that are being used--dieldrin and parathion and some others to a lesser extent. This is the mind of response you would get from talking to an agricultural authority in the area or from interviewing the farmers or even going to a chemical company that sells insecticides or any other source of information that is available. It

is not clear cut. And we have a persistent kind--dieldrin--which is highly toxic and we have a non-persistent one--parathion, which is short-lived but highly toxic. Both are being used in the county and being used by people who try to conform to the requirements of how it is used--the dose rates and so on.

S: I wish I knew what to do.

I: Where do you think you could go for help on this problem? What kind of a specialist might provide you some information that would answer this?

S: Could I go to an analyst...well, that wouldn't do much good anyway.

I: Just tell us what your question is.

S: If I went...

I. Start out first with what you want to know and figure out where you want to go.

S: I'd have to go to an analyst to find out which one is the stronger of the two, I guess. No...I don't know.

I: Before you are concerned with the strength you want to know which one is concerned, whether or not it is concerned at all with the particular birds. Or whether it is possible to identify the cause.

S: Don't tell me I've been going all this time and it's not the insecticide.

I: Well, it's possible, but you haven't proved it, you see. There are people who would be quite concerned about this and who might be forced not to use this material if it is proved that it is killing birds. We have to have a pretty good case.

S: The only difference is that one is persistent and one is short-lived?

I: Yes. But it is certainly true that if you consider all parts of the country each of these have under some conditions killed some birds. It is possible that either one of them could be the explanation in these circumstances. We haven't ruled it out yet.

S: If I go to the agricultural department could I...well, is it stronger in Jackson County than other parts of the country?

I: Is what stronger?

S: I mean is the death a lot higher...as the birds...a lot higher than any other section?

I: The amount of mortality we had recorded isn't necessarily higher. There have been other cases of bird die-offs that were just as high, but it is

definitely higher than most people normally expect it to be. It is high enough to cause people some concern because it did not appear before this period ten years ago when the increased mortality was reported. The size of the die-off itself is cause for alarm, but not atypical of pesticides in situations.

S: Which one...has either one of them been new in the last ten years? Either the parathion or...

I: Parathion is, has been used in the past ten years, but perhaps used more now than it was ten years ago. Dieldrin is still used extensively, but the amount of use isn't increasing very much. Both of them are used much more now than they were ten years ago.

S: The parathion, it was used before that, but both of them...

I: The dieldrin...I couldn't say specifically...both of them are used, say, three times as much now as they were ten years ago. Is the question that you are asking now, "Which of these insecticides...or "Did either one of them kill these birds?" Or is that not your question?

S: I'm trying to find out which one it was if it was one of the two or whether it was both of them doing it. I have to figure this out.

I: Is there any kind of approach you can take, any person you can go to, anything you can do yourself by way of an experiment or anything to get further answers?

S: Oh, I don't know about experiments, I wouldn't want to kill the birds, no. If I...I guess if I...now how do I do this.... if I figured out how much of the parathion at about the same rate that they would be getting it out of the field, whether it would affect the birds and the same thing with the other one and then I could do it with a couple of...well, more than a couple of birds I suppose, and find out how much it affects them.

I: This would be a good approach. Explain your experiment a little bit more.

S: In the first place I am going to take one bird...like a bluejay is one of them. I'll take a bluejay and then I'll have to go to a farmer and find out what per cent, how much he would use for his field so I could figure out how strong the insecticide is. I guess he'd know how strong it was in the first place.

I: Let me tell you the material he uses. Unfortunately, all the information he has is that he puts it on at a certain dose rate per acre and the aircraft sprays it. It might be sprayed at the rate of eight ounces per acre. Eight ounces of chemicals distributed in a spray over an entire acre of field.

S: Oh great...he still doesn't know how much it would be, then.

I: Right.

S: Oh, boy!

I: Where could you go for that perhaps?

S: I'd have to have my own acre of ground...Oh....you couldn't do that. You'd have to close off the birds.

I: I'm not sure you would need to spray a whole acre of field, but you could if you wanted to. The agricultrual people might provide you with some additional information there.

S: Well, they could...I guess if I went to the agricultural people they could tell me what the...how strong it would be, you know. If they did spray say eight...how much would it...

I: Well, they tell you that they think it is fairly safe to use this material at that dose rate. That it doesn't result in the contamination of human food and that to test it safely they have conducted feeding tests and other kinds of test on the laboratory animals. They tested parathion and dieldrin also on white rats and rabbits and when this testing has been done they have found how much it takes to kill them and they give you this information and they also can tell you what the residues are. When rabbits are killed with dieldrin under feeding tests, it does accumulate a certain amount of material in the tissues. And they will tell you also that dieldrin is a material which they are very concerned about the amount of residue in the tissue. If you're a farmer raising crops and you spray it you have to be assured that this chemical isn't in the food because it will go to people and will kill them and if you feed it to livestock the livestock will retain it in the fat. They won't permit but a half a part per million, I believe it is, a very small amount of dieldrin. Parathion is not a problem though we insist that the chemical tests of the food show very little of this material in it.

In their feeding test of rabbits they can tell you how much they put in. They fed rabbits perhaps a tenth of a part per million. It resulted in an LV-50 of--a feeding rate of ten parts per million would kill half the rabbits in the test experiment. A tenth of a part per million is the level in the food at which it would be critical in the feeding test on rabbits. They don't have any information on songbirds. But a tenth of a part per million is a pretty low amount spread over a period of time.

S: If they tested it on the crops and they found out how much it was and then they fed these crops to...first if they fed these crops to the birds could they tell what the percentage was?

I: They could analyze the crop and tell how much there is in the food.

S: Then do the birds die? No...

I: They are not eating the crop. They're eating other foods in the field. But they can analyze whatever the food is that the bluejays are eating.

So you find that they are eating weed seeds and insects and what not. Whatever it is they can analyze it for you.

S: Do some of the other birds eat the crops, too?

I: It's true. Pheasants might eat corn and so on.

S: But they mainly eat the insects?

I: Some of them eat grain. The grains are heavily eaten by birds. Root crops like beets are not too much. But we can get this information, too. We can find out what the amount is but the thing is as far as the crops are concerned there are almost none there because the agricultural department won't let them do it in a way that produces it in the crops. So this we have ascertained--it is not in the crops enough to even kill birds. But there is some in the environment sprayed on the vegetation and it's killing insects. They find it in the insects, they find it in weed seeds, and some of the other things. And we'll say these residue levels that they are finding are on the order of a tenth of a part per million.

S: And if the birds eat the insects will it kill the birds?

I: We don't know that. We can find this out.

S: I have tc go someplace else?

I: You have to test it on birds because it hasn't been tested on songbirds.

S: Oh, just not songbirds.

I: Well, not poultry, or chickens. Let's suppose that we do want to find this out. How would you go about testing? We know that a tenth of a part per million in the food is a critical level which can kill--some laboratory animals have been tested.

S: I'd have to find out where they are getting it. Are they getting it from the crops? I have to find that out myself.

I: What I think you want to do is to find out if they are getting it in their food.

S: Whether it's the crops or the insects or whether it is just by contact with it. I guess I'd have to experiment with it myself.

I: There are several kinds of experiments according to which question you want.

S: I see. Well, first of all I'd have to find out if they were put in contact with this and it wasn't in their food or in the insects, if it would bother them that way, if it was just contact without eating anything.

I: You can do that fairly simply by caging some of these birds out in an open area and having it sprayed. This is a good approach. You can use the same kind of spray the farmer uses. Without even knowing the amount that's on the food you can have a plane fly over with one swath and deposit the spray over these open pens.

S: If it was this, what is it, one millionth part, what did you say? A tenth of a part?

I: But that's on the material after the spray has fallen. Suppose you do this. You fly your plane over your pens and low and below a few of your birdies die.

S: I think most of them will.

I. Not necessarily. You very well could kill some directly with the spray. It just depends on the chemical.

S: That could be part of it. Then I'd have to find out if it could be from the seeds themselves and the same thing by spraying the seeds and feeding the seeds to the birds.

I: In this case you don't....how are you going to spray the seeds?

S: Just out in the field I guess and then you could take it back to the cages....

I: You could spread your feed out on some paper on the ground and spray it with a hand spray. I'm wondering--you're not doing it in the pen with the birds, are you?

S: Like I'd have the birds someplace else.

I: You want to protect the birds against the spray. Don't let them get any of the spray. Okay. You just spray the food. Then you feed the food to them. Now, you didn't say anything about the details of how much spray there is on the food. You do know that it will kill them if you do it this way.

S: Isn't it one tenth per million?

I: You don't know if that's what we've got in the food or not.

S: Was that just for the rabbits?

I: That was for the rabbits. You want to test this, or how do you want to find out? Can you compute how much is in the food?

S: I guess if you take it out and take it to somebody who could analyze how much there would be in it by taking a sample of the food.

I: Okay. In this case let's say that it turned out to be one-half part per million in the food.

S: In the other case it was only a tenth.

I: Only a tenth was enough to kill the rabbits.

S: How much was it for...no...Oh, great!

I: This can vary greatly, but we do know how much was in the food and we know that it was the food that killed the birds. They can die from inhaling some of these and they can die from eating it. So we have two or three routes and you have to distinguish them if you want to prove that it's one or the other, or you have to identify the chemical. As we got started on the work we were doing, were you fairly clear about what we wanted you to do?

S: Well, I just had to figure out where I was going, like to the library and all that stuff.

I: Did you find it hard to think about where you would like to go next, or did you find it harder to phrase the questions that you wanted to ask?

S: It was mainly the questions, trying to figure out what would come next to prove it. Then I guess you would have to be organized so you didn't have to jump back and forth like if I was really doing it, to go to the agricultural department to tell them what I wanted and everything.

Interview Number 4

Interviewer: We would like you two boys to start to work. Ask what information you would like.

Student: Did they have good nesting conditions, is that a fact? When you talk about Jackson County, you don't mean the city, you mean Jackson County, out in the country?

I: It could be anywhere. Presumably, the reports come from several parts of the county.

S: They have good food supply?

I: Generally. There's been no drastic shortage of insects or crops or weed seeds or whatever the birds are feeding on?

S: In the past ten years have there any great changes in Jackson County? I mean could it be like smoke stacks or something which are producing more smog and stuff like that which could hurt birds? Or what drastic change has there been in the last ten years compared to the previous ten years or the ten before?

I: You are asking two questions; let's answer one at a time. One question is: "Has there been an increase in smog in the Kansas City area in the past ten years?"

I: This is something you would find from the local newspapers or the public health authorities. I don't happen to know, but I'll just postulate that there has not been a great increase in smog. I don't know what the local position for smog is around here.

S: Where are they found in the city or country? Of natural death or disease, or what?

I: Which question would you like to ask first?

S: Were they found dead by disease, or what kind of disease...what kind of disease were they found to have? Or was there a disease?

I: The question is "Were any of these dead birds diseased?" How would you answer the question?

S: I guess you'd get a dead bird and analyze it.

I: A dead bird is submitted. A biology examination of the bird is made and the tissues cultures are taken, but they don't show any specific disease to account for death. You might also get a report that would indicate no other obvious cause of death.

S: I think you should take more than one. Take all the dead birds and see if they all have the same thing.

I: Okay, you gathered a group of birds which have been found dead and your question is...?

S: Do they all have the same thing--are they diseased?

I: No.

S: That's a fact?

I: It's a fact we give you as a result of our laboratory testing. None were diseased.

S: Was there anything striking as a group? Was there anything common among these birds? Was there any deformity or anything strange that you found about these dead birds that you possibly wouldn't find in normal birds? Not that there was any disease or anything, but anything abnormal?

I: Are you asking the laboratory? Some of these things you can do yourself. You examine the birds and may find some evidence. It may be that out of 20 birds you found two with broken bones, one with a broken neck, another with a broken leg. It's a very small percentage. Indications are that perhaps all the birds haven't died from the same cause, but one or two might have been injured.

S: For most birds...this is not exactly pertaining to this problem...but can you tell why most birds die? Can you perform an autopsy on a bird and see why he died?...if he flew into a brick wall or somebody shot him with a BB gun?

I: Sometimes. This is a basis for the explanation of one. If you find a broken neck or a broken wing, it could indicate that the bird flew into a TV tower, a power line and was injured. Even if it broke its wing, it would probably die because it couldn't fly and feed properly. At least the result of the autopsy, so far, doesn't account for the large increase but does account for an occasional death, such as you'd find if you searched for birds, and indicates that disease is not a single answer. The autopsy would indicate gross inspection of the organs didn't show any sign of disease and that the biological culture--the bacteria, which might be present--didn't reveal any indication of an epidemic.

I: Was your question: "By doing an autopsy, what all can I learn?"

S: It was one.

I: By doing an autopsy you can learn whether the animal has been shot, damaged or injured from flying into an obstruction or being attacked by a predator. In the case of large birds, like magpies or ducks, the kind of predator can be determined. If it were an avian predator like an eagle or a Cooper's hawk, you will find sharp penetrating wounds in the chest, or the forepart of the body, and maybe lacerations. If it has been killed by a weasel or something similar, you might find a broken neck or crushed bones. You may even find it eviscerated. Let's presume we have found no obvious predator. Maybe one or two birds show evidence of lacerations of the wing and body, indicating it escaped after an attack by a hawk. In the matter of disease, you can see evidence of diseased organs so you take a culture to identify the bacteria or the virus that might be present. Some things which cannot be determined with an autopsy, effect the physiology of the bird, yet no obvious evidence is revealed. You may not be able to determine whether the bird died from starvation, even though you could observe thinness of the breast muscle. The fact that fat was not present wouldn't necessarily give proof of anything. Birds commonly lay on fat during one term or season of the year. When they are in breeding season or during the winter, they use all their fat. An autopsy, alone, would not prove the bird was killed by some chemical. Chemicals wouldn't leave any obvious marks; more specific tests would be needed. You could send the bird to a chemist or a similar person to determine if any chemical poison was involved. You couldn't prove the birds were crowded out of the area by social strife. If there were over-population, competition and pressure, this may cause a common condition of stress in which birds are forced out of their normal habitat or perhaps die, secondarily to other causes. We have two evidences for assuming that competition for food is not severe. One, population is low; secondly, the food is abundant. If there were a high population and scarcity of food, competition might indicate a possibility to pursue. It is not indicated here because we already have a low population, therefore you would think if any birds were present they would have more than enough food, nesting places and so on.

I: I should mention that a very common finding from autopsies in large birds, such as eagles or pheasants, small lead shot resulting from somebody shooting the bird with a shotgun. You might even find a bird that was killed by a bullet. Usually the bullet will go through, but often you can recognize a gunshot wound or find a pellet or two of shot which may cripple a bird, injure it or result in its death later because the bird hadn't been retrieved. The bird was just a victim of target shooting or was shot and flew away so that the person couldn't retrieve it.

S: Could you find something about the death of the bird from where it was found?...or even the condition it was found in? Was it lying on the ground head first, or was it lying on its back like it had fallen and gave up life? Was there any similarity in why they were found dead?

I: This is a possibility which could throw some light on the thing. You're asking for general background information. If you want to ask about particular birds, that's another question.

S: Where were they found dead mostly in the city or the rural areas?

I: This we could probably get from the birds that have already been reported When we checked with the people who gave reports, about all we could find was the general locations. People haven't described the positions of the birds, or whether they were partially covered, or if their heads were down or up. They do say that the birds were distributed over, perhaps, about half of the county and in more than one area--mostly in the agricultural areas. A few were found at the edge of suburbs.

S: So they didn't find too many in the city?

I: No, mostly in the country.

S: There was nothing, when the birds were found, that was similar?

I: They weren't all in the same kind of field or.... You have a suggested association with agricultural areas.

S: They don't cropdust or anything do they? Do farmers use any kind of chemicals or anything?

I: Where would you find the answer?

S: Maybe to a company which sells the chemicals that affect birds.

I: You have two questions going. The first is: "Do farmers use these kinds of chemicals?" Do you want to put the question to the chemical company?

S: Maybe the department of agriculture.

I: The department of agriculture certainly would have information; they would say yes. They don't know specifically about Jackson County, but they do know that a number of chemicals are used for crops grown around Missouri and Kansas, and they know the chemical companies.

Guidelines are distributed to the agricultural extension agents, the local farmers, telling what chemicals are used. You can find the chemicals recommended to kill particular pests and crops if you know what is grown in the area. You may be referred to the Jackson County agricultural advisor or agricultural specialist, who knows more about the local situation and has the guidelines of approved pesticide uses. You can carry it further if you like.

S: You say there's a pesticide which kills insects and such?

I: There are several kinds; insecticides, herbicides that kill weeds, and so on.

S: Maybe they affect the insects...then the birds eat the insects and the poison in them could affect the birds.

I: Would you like to pursue it?

S: You can take your laboratory equipment and put some of this chemical in the insects...make a large count so that you could examine the insects to see if they take it into their system. Maybe the birds, when they eat the insects, are affected by the chemical.

I: Your question is: "If insects eat these pesticides, do they retain them in their body?"

S: Yeah, and then die later.

I: Yes, some do. The usual intention of the farmer, who has his field sprayed, is to kill the pest insect quickly, but he can't avoid spraying the other insects in the area. Normally, not many pest insects survive. Some other insects and invertebrates, like earthworms certainly could survive, and undoubtedly, would carry some pesticides in their tissues. Some of them wouldn't die. It's undeniable that many non-target insects--as they call them--such as honey bees or beneficial insects would die also, but not all insects die from insecticides. Some get a lower insecticide dose or are not as sensitive to it. Nevertheless, they have been exposed, which presents a possible hazard to birds eating the insects.

S: We're going to run an experiment where we take 50 insects that have... 50 birds. Okay, we'll take a hundred birds and split it, with 50 here and 50 there, and feed the birds--one 50--a normal unchemically-treated insects (the chemicals will be just the type that the farmers would use in this vicinity) and take the other half and let them feed on the regular insects which would not have those chemicals that have come into being the last ten years.

I: Okay. You've been feeding them. What do you want to do now?

S: I want to see if there is a higher ratio that eat these chemically-infected insects than those birds which don't eat chemical-infested insects, but eat regular, normal insects.

I: Repeat what you want to look at.

S: The two groups of birds would be the ones which have chemicals that had been introduced in the last ten years; another group would be the birds that have eaten insects which don't have the chemicals introduced in the last ten years.

I: Now what do you want to know about the two groups?

S: If there is a higher ratio of deaths of one to the other, or if the ratio is about the same.

S: It would have to be higher.

S: But, I want to know how much higher...if it's like, maybe one percent. It doesn't give a total answer, but if it is something drastic...like seventy-five percent more in one group dies than in the other...

I: In other words, you are not expecting a complete and absolute difference?

S: I'm not expecting it.

I: Let's look at the test. A month later we have the results. It shows that of 50 birds put on what we can call clean food--having no chemical--five died. Of the birds put on the contaminated food, 20 died. So, we have that much difference between the two.

S: That could maybe one answer?

I: It could account for it, yes.

S: And these birds that don't die...we find the birds that don't die. If we take the 45 birds that eat the clean food and 30 that eat dirty food, could we now run checks to see if there was...? That would be two experiments I have in mind--one, check the dead birds and see if they have any similarities to the ones that we found in the field.

I: What kind of analysis would you run?

S: Some chemical analysis to see if the chemicals found in this dead bird were similar to those in the other dead birds.

I: Well, we can do that. What would you ask the chemist to analyze? Insecticides in general?

S: The insecticide that was put into their food.

I: We haven't identified it yet. Let's assume it's the same one for now. The chemist will give the report back showing that, in the five dead birds eating the clean food, low levels of DDT and DDE were present. If you ask why DDE is there, they will say it is a breakdown product of DDT, and it is produced in the body by DDT. These low levels amount to about two to three parts per million. There are also residues of dieldrin amounting to five parts...no dieldrin in the birds on the clean food...

the birds that are on the contaminated food have levels of DDT amounting to one to two parts per million, but, in addition, dieldrin residues are found amounting to say four or five parts per million.

I: The dead birds found in Johnson County would have residues of dieldrin of, you might say, two parts per million; some one to three parts. They also would have a little DDT present.

S: Could we say one of the causes would be this dieldrin?

I: It's a very likely hypothesis. I'm not sure we've proven it yet, but we've some strong evidence. Would you think the DDT is a possible subject of suspicion?

S: You said DDT was in the bird's body. If I heard right, you said there might have been more DDT in the birds which ate the dirty food.

I: I didn't intend to give you any significant differences. Some was present in both. If it was a little difference I shouldn't have indicated it was enough to matter. Let's say it was the same or is a variable amount.

S: Could we find which specific chemicals would have something that could give dieldrin to birds through the insects.

I: Information from the department of agriculture would tell you that dieldrin is one of the major insecticides used in the midwest region for pest control, and that it is also a breakdown product of another chemical which is aldrin. When aldrin is sprayed on crops and is consumed by animals it is converted to dieldrin, which doesn't help them because dieldrin is just about as toxic as the aldrin is. But, dieldrin can come from two sources. In any case, the result doesn't matter, but we do have the use of aldrin as an insecticide which is a possible cause of death. Where would you like to go from there? The agriculture department hasn't told us that it is being used in the area, but you can get that information if you want it. Presumably, we have ascertained that dieldrin is used in Jackson County.

S: More in this ten years than the last? They tell us there has been an increase of use in the last ten years?

I: Is this a new fact that you didn't know before but know now?

S: What was that summary?

I: You have been able to get the information needed from the chemical company which distributes and sells it. They give you figures showing an increase in use. The use in 1968 was four times as much as it was in '58.

S: Could we check the number of birds? Was there any difference in the ratio of birds? If there was four times as much chemical used, was there any sort of ratio to the number of birds killed...say four times the number of birds killed in '68 as in '58? Where would you go to find out?

S: Well, from the people who gave us this little problem.

I: Let's say these people are members of bird clubs and have been in the field watching birds and found some, or have talked to farmers, who have reported these birds. This is the source where you got the birds for analysis. Some bird club members say they have been interested in birds for a long time and that they habitually make bird walks in the country to watch different birds, In their opinion there has been an increase in mortality. They used to occasionally find a dead bird, but didn't find very many. We check into the field notes and different observations. Members of the club offer opionions, which aren't too firm, suggesting at least twice as much mortality. But, they are not sure that ten years ago there was any increase over what they would normally expect. We don't have firm figures on what the mortality was ten years ago, but it looks as if it is twice as much now.

S: Could it be in the water? Is there any kind of disease in Jackson County water like typhoid, like sewer water?

I: Where would you get this information?

S: Would you go to the city?

I: They might refer you to the health department. The health department would tell you they don't have any high incidence of typhoid. They think it is well under control and their water supplies are pretty clean, and, in any case, they don't know of typhoid cases occuring among wild birds.

I: When you said the water was pretty clean, I wasn't clear what all you meant.

I: I mean the common source of typhoid is water when it's from contaminated wells. Usually the wells have been contaminated by other sick people. They test the tightness of the well--check that surface drainage does not get in--and report no major problems in the last few years of contaminated water supplies--from sewage leaking into wells, or anything which is commonly associated with typhoid. This lead does not help us because it isn't related to a wildlife disease. They suggest you go to a verterinarian for information on wildlife disease.

S: Okay, let's go with that dieldrin; it looks like a prime suspect. We tried running tests to see what proportions were running over a ten year period with deaths and the use of this dieldrin. I'm trying to think if there are any other tests we could run.

I: We've established there has been an increase in mortality; it isn't necessarily in the ratio of 4-1. We haven't established any reason to believe that it is 4-1 just because the amount of dieldrin is 4-1. There might have been no deaths from dieldrin ten years ago. The ratio is increased which supports the hypothesis.

S: You said the rate of death of birds did not go up with the ratio of dieldrin used. Maybe they built-up...they became less susceptible to it.

I: You are interested in the mortality rates in birds and population dynamics in the general field of what we call ratio of population levels--the rate of births and the number of deaths and so on. If you would be interested in pursuing this matter further, how would you do it and who would you go to?

S: Would the department of agriculture have anything to do with wildlife?

I: Fish and wildlife service or the state game commission or the university, zoology department might have some information. Among other things, I think they explain the population which exists at any time is the result of a certain rate of reproduction, or birth rate, and at the same, is the results of a balance between birth and mortality rate. If the mortality is low and the reproduction is high, the population will increase. As population increases it reaches a certain ceiling, which is the carrying capacity of the land in a normal habitat. If the food is limited, or the proper cover to protect against predators or enemies is limited, then the population goes beyond the ceiling. The mortality increases, either by starvation from lack of food or by being killed by enemies. The mortality rises to where it equals the birth rate and the population stabilizes. If mortality is unusually high, such as for disease or anything else, the birth rate isn't able to replace the loser, then population declines. You have this balance and probably, also, a fair amount of information on the possible causes of mortality which we have already considered. Population dynamics works in such a way that normal death rates found results from several interacting factors--not just pesticides or something else. In Jackson County mortality is higher than normal, which we know by comparison with what the bird club members found. However, other factors are operating which will influence the final result, to some extent, and account for the fact that our ratio is not 4-1. We can only assume the ratio will rise with the chemicals used, if the chemicals were the only cause of mortality; but they aren't, you see.

I: Ten years ago the mortality could have been at a certain level just because of the food available.

S: You say this is Jackson County's problem. Could we check with the department of agriculture to see if other counties in the nation had similar problems and if there were any similarities between the problems... if they have any ideas...if we can compare notes?

I: What counties would interest you particularly?

S: Taking the birds which were killed mostly in agricultural sections, I would find a county that would be agriculturally...just very similar to Jackson County in type of land, climate, the very things which pertain mostly to the birds--climate, weather, food, crops grown.

I: They could give a suggested number of counties; some might be in Missouri, some in Illinois. Let's say the results for several counties are similar--

we have one other county where there have been reports of high losses of birds--, but most of the counties are somewhat similar in agriculture and habitat. Some counties don't have bird losses. They have different patterns of insecticide use and have no particular, severe outbreaks of insects so there's less insecticide use. One other county has heavy insecticide use and has had reports of bird losses.

S: I will check counties which did not have high losses of birds. Insecticides were used but were different from ours. Did they, in some way, not have dieldrin or not have a chemical that would bring about...?

I: Some didn't have any major pesticide problems and there wasn't any great use of insecticide. Others had one or two outbreaks in which a material called malathion was used. Twice as much malathion as dieldrin was used in Jackson County. Where do you go from here?

S: Well, that chemical just wasn't as bad as this one!

I: How do you find out? I'm not going to tell you unless you ask me.

S: We can plan a few more experiments.

I: There are possible ways.

S: Wasn't that chemical as bad on the birds?

I: We have no reports of bird mortality in the county which had some severe insect outbreaks with heavy treatment of malathion. As a matter of fact, they sprayed twice with malathion; in the early summer and later. There was fairly good insect control. They were very happy because they think their problem was solved.

S: What about the chemicals they sprayed for the Dutch elm disease?

I: That's DDT

S: It's been proven that the chemical sprayed for the Dutch elm disease does not kill the birds?

I: It depends on how it's used. The common one that has given trouble with Dutch elm disease is DDT. In some cases DDT has caused no trouble, but in the case of Dutch disease it has killed a lot of birds. You can find this true from literature, since it has been studied extensively. It has been identified why this disease has caused bird mortality when used for Dutch elm disease control--mainly in urban and suburban areas on shade trees. I'm not hypothesizing. If I were, a number of your preceding questions about Jackson County would have been different.

S: When we went back to those counties a few minutes ago you said one county was just as bad off as we are, worse.

I: It is, so far as bird mortality is concerned.

S: Were they using a chemical similar to dieldrin?

I: They were using dieldrin. There is another county did not use dieldrin in their pesticide spray program, but they used malathion. The use of malathion was actually much greater than the use of dieldrin in this county--twice as much malathion was used, but with no bird die-off.

S: It shows that malathion wasn't as potent to birds as dieldrin?

I: That's certainly a possible explanation.

S: Since no malathion is used in this county that wouldn't bother us too much, except to say the chemicals would be a great factor. Now going to this other county where dieldrin was used. It seems, from what has been going on, that only the counties using dieldrin had really a high and bad mortality rate among birds. I think we know this pretty well...I think we can almost pretty well put it on dieldrin.

I: Do you have any reason why you are reserving judgment?

S: Because we haven't gotten any real, clearcut experiment which would show it yet. I think I would mentally go to dieldrin.

I: You have strong indications. We are going to have to stop the investigation now, because we are running out of time. We want to get some of your reactions. When you went to work on the problem, was it clear what we expected you to do?

S: Not completely..you know, not flawlessly clear.

I: Can you think of anything in particular we could have told you...or did it have to come as you worked on it?

S: That's the way...it had to come out.

I: Did you find we gave you the information you thought you would get if you chose that route, or went to that place to get it?

S: It sounded like it was the right information and was also rather helpful information.

I: What do you mean?

S: It sounded like different ideas...it wasn't so specific that, when I needed specific--like when I got to dieldrin--it helped to go on. In some spots it was general enough so you could have a choice of whatever fields you wanted to check. It gave enough to think...well, it could be this or it could be that or possibly none of them at all. It left me pretty free and I was able to choose my own route.

I: Can you think of anything that made you uncomfortable?

S: Only at times when you were silent.

I: Was there any time when you felt a degree of frustration, or of not knowing which way to go?

S: Only when I first read the problem.

I: Was it from the nature and complexity of the problem or from the situtation of not knowing the ground rules as to how you would answer the question?

S: The situation and also ground rules, because I wasn't really sure whether I was going to get general answers or specific. Also, it is kind of a deep problem because there are two different kinds of life here...I mean it is kind of a complicated problem.

I: We tried to clarify we are not accusing the agriculture department of being careless and saying there are necessarily widespread die-offs. They occur occasionally, but very often the die-off results from much more complex chains of events than even this simple one. Direct kill from the longstanding chemicals of widespread use doesn't happen often. Even though some are toxic, they are generally used at a low dose rate. But, long-term, secondary effects are becoming more and more troublesome. They are troublesome because we have established usage patterns for certain insecticides which have clearly defined consequences. With a long-term, secondary use, you can't always prove exactly which spray program was the source of the trouble. In this sense, we tried to set up a fairly simple one--the sort of thing which happened maybe eight or ten years ago but doesn't happen quite so often now. It happens nowadays with the first use of a new chemical--thought to be fairly safe--applied on a fairly large scale. Maybe later it is discovered to be unsafe. One today is, hazadrin, which probably never should have been licensed. It was registered on inadequate information. Conservationists are making efforts now to get it deregistered, which is very hard to do. The chemical company feels they have a vested right in it now since costly production effort is underway. They say the burden of proof should be on the conservationist--to make airtight proof of its serious loss which is a lot harder to do than giving serious grounds for apprehension of its causing loss, and that it shouldn't be registered. Many times the chemical companies are much more cooperative in refusing to proceed with the production of a material which might get them into trouble. Once they have it registered and spend one or two million on its development, naturally they are very reluctant to cut it.

I: Do you have any other things you'd like to tell us about the experiment or about the problem we are pursuing....Any general reaction to what you are doing?

S: I wouldn't have gotten that far if I hadn't had this library.

Interview Number 5

Interviewer: You can begin asking questions to help you learn what you would like to know.

Student: The first thing I would like to know is how often are these trees sprayed, or what nesting conditions are there. Are they in trees, or are they in houses, or what is the situation that they live in?

I: Is your question what kinds of living conditions are these dead birds found?

S: No. I want to find out what or where they live. Do they live in trees, or do they live in houses built for them like a martin house, or something, or are they in a closed-off area where they live...or where?

I: I can't quite answer it yet because I am not sure what birds you are talking about, and as to whether you are concerned specifically with the ones that have died or birds in general in Jackson County.

S: I would say birds in general.

I: You can find out fairly easily from the library. There are quite a variety of birds in Jackson County. If you look up the birds in Jackson County and Missouri, you will find the kinds they are and that there are well over a hundred. Now as where this particular problem arises, how would you go about determining that?

S: I imagine I would put this into maybe three categories. I'd want to know if they record to find out how often the trees are sprayed, because maybe that would have something to do with it. Or I'd like to find out how bad the air or the pollution system is. I'd like to find out whether or not the food or anything has been contaminated by anyway. I'd carry on tests maybe in a lab and I'd have to go down to the city and see if they have any records about this kind of spraying. I'd like to look up some records someplace about the air problem, because that could be it, very well.

I: What would you like to start with?

S: Let's start with the tree spraying because I've noticed an awfully lot in the last two or three summers.

I: How would you go about finding out? Wherever there was tree spraying?

S: I imagine they would keep records such as how much is used and what sections it is used in and what day.

I: I presume the city government could tell you. Suppose they tell you in the suburban areas of Jackson County there has been spraying. In the last

few years they have been spraying the elm trees, and it is a very beneficial program. It's being done because we are suffering losses of elm trees from the Dutch elm disease which is transmitted from one tree to another by a little bark beetle which bores into the bark and infects the tree with a little fungus, which kills the tree. In order to prevent all the trees from dying it is necessary to spray them with DDT. There are actually other control methods that are important too, one of which is scrupulous sanitation and quarantine--cutting down and burning all infested trees. They spray the trees with DDT, essentially the trunks, the bark, to kill the bettles that emerge from the trunks and fly to the next tree.

S: So if they told me about the DDT and the beetles, well, birds do eat bugs and things. That could be a way--the DDT in the bugs. Would it be one situation.

I: Yes

S: Has this DDT been tested on wildlife?

I: You say has it killed wildlife?

S: Yes.

I: Under some conditions. On test animals there are reports which are available which describe how much it took to kill different kinds of test birds and animals. The birds tested by the Fish and Wildlife Service have usually been a few standarized species, mostly pheasant, bob white, quail, mallard duck and few other species, like Hungarian partridge. They know how much it takes in a single dose to kill each kind and how much it takes if you put it in a small dose and feed them a little bit every day in food.

S: Would it be sufficient enough?...Amount? You know, if it is just a single dose in the beetle...if the bird eats that beetle, would it be enough to kill him or do him harm?

I: We can't say in respect to the beetle because we don't know how much is in the beetle--or how many beetles they eat. This will have to be determined. I can't answer you question directly except I can say tests of DDT clearly show that low levels in food eaten over a long period will accumulate to the point where it will kill birds. They might die as long as several weeks after they first start eating. After they accumulate a sufficient amount they die. We can tell you the approximate amounts in the diet on a feeding test would have to be between one and three hundred parts per million in the diet. If you had a diet with 250 parts per million and you fed the birds for 30 days, you would begin to have some pheasants dying.

S: Now, you don't see too many pheasants flying around in the city, so I imagine with the small birds a smaller quantity would kill them?

I: I'd better clarify two expressions you would learn from the government or the library. One is the amount in the diet is expressed in parts per million which is a ratio or a fraction. In case of DDT in a million grams of food, it would be expressed as one part per thousand kilograms--a very small fraction, but in proportion regardless of how much you use. It would be two grams for two million parts, and so on. In terms of amount it actually takes to kill the animal, it is usually expressed in milligrams per kilogram of body weight. The amount of material to kill a bird would be a particular fraction of its body weight. The ratio is what's determined. For a hummingbird it takes a tiny fraction, but it is in the same ratio of the body weight, even though in the pheasant you would have a larger amount.

S: You're going to have to round up all possibilities before further experimentation; otherwise, if you don't have all your material you're not going to get anywhere. So the next thing I imagine I would do, would be to dig up some records or something about the city's air. Oever the last few years there has been...I imagine there has been more materials produced in the city, more factories that have used more than they have been...and I imagine it would result in a lot more pollution. I imagine the cars, a lot more cars...let's see--all material has waste. There is only so much which is useful, so I would imagine it would have to do with the waste products, tool....

I: What question would you ask or how would you go about this?

S: I'd ask, what is the ratio of pollution to air? How does it change from year to year?

I: In the city? You would go to the government authorities, the city government. You would be referred to the health department where they have people who would tell you, I don't know exactly what the situation in Kansas City is, but they might say they have figures on air pollution in Kansas City over the last 20 years...the figures show some increase...they are concerned about the matter...the air standards are being established as a basis for obliging the industries and power companies to put improved devices on stacks...there has been an increase in the last ten years to perhaps double what it used to be, but they don't think it is alarming. It doesn't compare with Los Angeles, for instance. Figures can be given if you wish, but they don't think it has reached a serious level yet.

S: There is more kinds of pollution than just air pollution. You have to find out what waste is pouring into the rivers and streams and how it accumulates and what damage it does to the waters. There is a stream which runs out at about 95th Street with soapsuds floating down it all the time. It's just terrible. I'd like to find out about the water pollution.

I: Could you make your question precise or specific?

S: How much waste material do the factories pour out into the stream everyday, or the city pour out into the streams? Like bath water and washing water and toilet water and stuff like that?

I: Depending on who you ask for information, it is hard to present a possible answer to you. But, you'd get something like this from some agency or other I think! There is a substantial pollution. It consists of two kinds. First, a heavy discharge of sewage, only some goes through treatment plants is not thoroughly treated by any means. The growth of the city is faster than treatment plants can keep up with so an extensive pollution of the river downstream from Kansas City exists. There is also some pollution of the rivers--the Kaw River and the Missouri--before you even get to Kansas City, which causes occasional impoverishment of oxygen to the animals, fishes, invertebrates, and other things in the river. Steps are urgently needed to clean up the rivers. In addition to pollution which depletes the oxygen content in the water, there is the chemical contamination from certain industries in the area. Suppose the chemical pollution has been going on ever since World War II--Twenty-five years. The water pollution has increased as the result of pollution. How would you pursue this now as a next step?

S: It seems that we have been taking birds from the cities mostly. It says birds in Jackson County where there's lots of wooded areas, like out where I live.

I: Yes, it has rural areas.

S: I think that I will go back to the beginning and see where most of these birds are found. If it's in the city, well then I'd keep on the track we are on. If it's more in the country--you know, equal like--go to the city and go to the country on a field trip and try to find things in common. It says the food supply has been adequate and nesting conditions are reasonably good. I'd try to find common environment or...

I: How would you go about this?

I: As I understand, you want to identify these bird losses with the rural or suburban areas or with the country areas. How could you determine where these are?

S: Well, first find where most of these dead birds are and then take a field trip out to the place to look for yourself and try to find some.

I: Whoever reported the birds would tell you some were on the edges of the city, but are in residential suburban areas where trees are. They're being reported by local residents and bird club members, but we haven't had many reports from far out in the country. Also, these are on upland areas...They aren't just along the river bank....They are in the streets in town.

S: Then I'd go back to tree spraying and pollution in the air. In the suburbs it's not too bad. I would just try to find maybe disease in food or water contamination.

I: How would you go about exploring?

S: In the past ten years they have been found dead. I'd say go before that. Was there a lot of tree spraying when these communities first started developing? What they did before, like if they sprayed maybe 15 years ago...then all this spray has been building up over the years...it has just now gotten to a sufficient amount to kill the birds in the past tne years.

I: Is your question what has the history of bird spraying been in suburban areas?

S: Yes.

I: The history of spraying you could get from the city people. They would tell you the Dutch elm disease started in the eastern United States. It was introduced from Europe and spread across the country reaching the Missouri and Kansas border some years ago. It wasn't a problem of serious magnitude until 10 or 15 years ago. Then they began spraying the trees, which is more extensive now. There is another aspect of the question. I'm not sure whether you presented it. Is this what you wanted?

S: After these two, I think I would pursue the third thing; whether the food and environment were adequate. You'd have to find what kind of birds there are; what the most favorable environment would be; the best kind of food for them. You can get a lot of birds together and some can't take the same temperature or the same conditions that other birds can. And some birds can't eat the same foods that some birds can. You have to find out about the foods.

I: To start with, one of the most abundant birds that is dying is the robin. There are a few warblers and a few jocos and other species, but robins and mocking birds are the principal birds.

S: Could it be a lack of food supply for the larger birds? or are they just dropping off?

I: You mean the robins compared with the warblers as a smaller species?

S: Yes. Like at Swope Park you've got hawks flying around all the time. You can go out there and see five or six of them circling around all the time, and go to a different part of the park and see a different five or six. I was just wondering, do the birds attack each other if they are hungry enough or would a pigeon go after a robin if he is hard up for food?

I: The question relates to general bird behavior which you might find from reading about the life history of birds. You are concerned with competition between birds which does take place to some extent, but usually not between such unlike birds. If you are talking about a hawk it isn't really a matter of competition. Some other hawks will feed on other birds whether food is abundant or scarce. If you're talking about birds that feed on grain and that sort of thing--like doves or pigeons compared with sparrows--usually they are adapted to feeding at different sites and in a different manner so there isn't too much competition. Competition is usually between

related species. I don't think you will find very much information on instances during food shortage where pigeons would drive out smaller birds and monopolize the food. Usually the smaller ones disappear and become scarce. You might find the pigeons disappear, under certain circumstances.

S: I'd like to know now...I imagine I would have to go to a library setting or to move to the city...to find out if the bird population is increasing. If so, then I'd have to go on a field trip to find whether it's just too much crowding--somebody trying to move into another's nest and another trying to protect it...

I: From your field trips you find, in these cities, some of the birds such as the robin and the mockingbirds are found dead. They are not very abundant; the local residents tell you there used to be more. They know what happended. There just aren't as many robins around anymore. You find this confirmed when bird club members report seeing casualties. I think it is more or less implied when there has been a decline in Jackson County. My answers that I give you would have to be compatible with an adequate amount of food, as far as general observations go. But an increased incidence of dead birds...it doesn't say whether they are over or undercrowded, does it?

I: Your own servey shows birds are, if anything, more scarce. They are fewer in number than they used to be, in accordance with the observations of the people in the bird club, who have been observing this for the last ten years.

S: We have already gone through two things--air pollution and the tree spraying. It says the food supply has been adequate, but has it been good for the birds. Could it be polluted with something. Maybe the tree spraying material has gotten on the food, its seed, or the seed has been washed or kicked around or something like that.

I: How could you go about finding that out?

S: I think I'd take it two different ways. I think I'd take a field trip and I'd also try some of this food in a laboratory to see if I could break it down.

I: What kind of food would you collect?

S: If birds eat a lot of seed...I imagine a lot of people just throw seed in their back yard...I imagine I would take this bird seed, or something like in which has already been outside or something. I think I'd take a pretty good amount because it is not likely that in every grain you are doing to find it. I imagine it would be pretty long and backbreaking, but that's one way of doing. I imagine I'd take it into the laboratory and test it under certain conditions.

I: What would you be looking for?

S: I think I'd be looking for...waste materials from the house. Like a lot of times somebody will spill something....like a little kid will spill something and they don't want anybody to know about it and they will pick it up and clean it up and just leave the spill. A lot of times, people could just not even want the birds around, like pigeons. I know out on my block they shoot them. Go out and take a pellet gun or B-B gun and see if they can scare them away or something. I think that I'd try to find out what kind of food because a lot of times they throw out in the back yard and I think I'd take some of that and test to see if there would be any kind of contaminating substance in it like some kind of poison or something.

I: The test results say there are no identified contaminants in large amounts or any amounts to be of any concern to human health or for domestic animals. You might find a mere trace of something like DDT which would be possible. It is very likely that even food material from the house like bread or grain that would be put out for the birds...bird seed might very well show a trace of DDT.

S: Well, I'd like to find out if there was any bread, if it was lift out long enough whether the mold would have any effect on the bird.

I: How would you do that?

S: I imagine I'd use a library for this and look it up and see if I could find anything about the mold on bread and how it affects animals if taken internally.

I: Some of the molds are certainly toxic. Some animals if they eat moldy hay or moldy foods will get sick if they eat too much. I should also point out that feed for animals, if it becomes moldy, is usually quite unpalatable and usually the animals won't eat much. They will generally stop eating before they get enough to become seriously ill. In some instances they get a lung disease like tuberculosis, which could be identified by x-rays. Normally, this is not something that occurs because animals don't normally eat moldy food. Chickens or livestock are the only ones I think you'd find information on because I don't think there is anything on wildlife or songbirds. But you'd have this background information which you might find in the library on livestock and domestic animals.

S: I think that I would then go...may wish I had gone there first...is, you know, get a lot of these dead birds and examine them and see...like an autopsy maybe. And find out what could have killed them.

I: What would you look for in this autopsy? Okay, how many birds do you suppose we could gather together? Say 50 birds were picked up dead, here and there. Let's suppose that out of these 50 birds, perhaps eight showed

some signs of injury. Two of them had broken necks and three or four had broken wings or other injuries, and one or two had lacerations or injuries. They look as if they had been scratched or clawed. The rest don't show any damaging marks. They are intact and limp, as though they died from a disease or poison. What is your next step?

S: First I would assume that those few which were damaged externally...it may happened in a fall...or maybe an animal got to them and they were killed or something. I would take the possibility we have with the DDT; go back to where the research on these birds and find out how it affacted them; actually stop functioning, whether it was their lungs or what.

I: If you'd read the reports of the tests run on DDT? You know when birds are exposed to DDT--and they receive a large enough amount...that they become adversely affacted; the first things affected are their muscular coordination and control. They have tremors; quiver; they can't fly very well; they lose control when they fly. If they get off the ground at all, they fly around a distance; then, come down and thud into the ground. They can't break their flight; they can't see where they are going. The final result is death by paralysis. They can't breath anymore. This is what you'd see in wild birds if they were in the last stages of dying.

I: Is there anything else you would like to know?

S: The condition of the bird after he had been killed.

I: It does show anything by the way of a gross anatomical thing you can recognize. It may go into a convulsion causing it to die with its neck stretched out in an awkward position, but not necessarily. You can analyze the bird's organs and tissues to find what chemicals are present. If the DDT is present, it will show up in the chemical tests--even in very small amounts. They can detect it to less than a part per million.

S: After these chemical tests and everything, I would go back to the bird's environment.

I: Well, did you mean to test these birds?

S: Yes

I: Then I'd have to tell you the results. Of these birds that you tested--the 50--we'll say they all had some DDT present. Most of the birds had amounts ranging from 10 to 150 parts per million, but perhaps the birds with these injuries had the lower amount. They had between 10 and 50 parts per million. Some others had as high as 150 parts per million in the body.

S: Still, you could say the birds injured could have been injured in the fall, if they fell out of a tree. They could have been injured by another animal,

like a cat or something, or they could have been run over...a number of things; or a broken wing;...like somebody will come to pick it up by the wing, carry it and then throw it down. I think I'd stick with the DDT part and see if I could dig some more out of there...out of the environment....see if I could dig some more about the beetle and just exactly how much, how many beetles birds would eat. I'd get about five or ten birds; then, get so many beetles, put them in the same closed area and just let them have at it.

I: You could, if you fed them on the beetles, but they would be hard to get. You'd probably find that one bird could eat quite a lot of bettles--50 or 100. You might also determine how many grams of beetles they require in their food. What else would you like to know?

S: I'd like to take a different set of bettles and find out exactly how much DDT they hold when they die. Like you take a beetle; you put just a drop on him. If he dies, you figure how much thei drop was. Like just put 1 milliliter in a--something, and just put that on him.

I: The chemist can conduct a toxicity test. He can kill lots of beetles until a quantity can be weighed. Then analyze them to find how much is present. There might be so many milligrams of DDT present on the number of beetles such as a bird, like a mockingbird, might eat in one day. You could multiply by whatever number of days to find out how much they would eat in a week or month.

S: If they ate so many of these, it could take over a period of a week, but if this was their main food supply--outside of the normal stuff that people set out--then I imagine it would be a fairly...you figure you only had ten to 150 millions...?

I: Parts per million. Don't worry about the magnitude because we are dealing with substances which are very effective in extremely small amounts and doesn't mean they don't kill. You're just talking about units not familiar to you.

S: I mean in some birds you said it takes 250...if there is so much of this it's going to be passed out of the body as waste.

I: Right...and it takes a period of time to accumulate. What we found in the beetles is just the amount in one meal. You raised the question about food habits. How would you answer how much beetles? What next question would you ask; what investigation would you make to pin down the matter of the two principal species--at least, the robin and the mockingbird, and the other one you wanted?

S: I would find how much of each they would eat--of regular bird seed, or whatever they normally eat. How much the beetles eat of this or that; if both of them were present at the same time. You could put out so much of both, and then whatever is gone....I think I would only use one bird, but from each section. I'd use three to four different birds, but I would have them in different cages or something.

S: Where you have three or four birds, one could eat more than another. You would still want to know how much did this one eat when he died; how much did the next one eat?

I: One question I have is what exactly do you offer to each bird in each cage?

S: I think I'd offer the birds so much seed, like maybe a cupful; and so many beetles, maybe 100. Then I'd contaminate these beetles. In two I'd contaminate the beetles; in the other two I'd have the beetles alive.

I: You would have the grain, or seed, in the same cage with the beetles?... they had a choice. In each case the bird would have the same choice except for the two cages where the beetles would be contaminated.

S: And then, would the birds eat the dead ones as much as the live ones?

I: We'd better not get too many things said before you get the information. You can run as many of these tests as fast as you can ask questions. So the first test shows they eat very little grain; they eat some beetles, particularly the mockingbird eats a number; the robin hardly eats any at all. The birds seem to get weak; they are not doing well in the cage.

S: All of them?

I: Yes, all of them in all the cages.

S: And they haven't eaten much of the bird seed either?

I: They've hardly eaten much of the bird seed?

S: Then you'd have to say they are not getting the right kind of food.

I: Okay. How do you go from there?

S: You would have to test kinds of food like some bread and find out if they would eat it. You might even have to test the bird. If the bird died you might have to find out just what exactly...like break down some of his organs. In biology we find that certain organs need certain proteins and stuff like that. You might have to find out what materials they need, and that would help. Find foods which contain these things birds need. Because if birdseed does not help any of them and they're not eating the beetles and they're dying in all four cages, you're kind of left in the dark.

I: I think you need to know more about the proper food for birds. Is there any way you can get the finformation you need which would get you back on the right tests so you wouldn't.

S: I'd go to the health department for wildlife; maybe the county office.

I: Or the game department; they would tell you birds are difficult to keep in captivity and are not seedeaters like the sparrows. Birds are mostly insect-eating birds. Its true, some eat beetles--rather large birds do. These beetles are pretty small. It's very difficult for the birds to get them out from under the bark, where they live. The birds you are dealing with don't usually feed on tree bark. They feed on the ground where they find grasshoppers, grubs, and earthworms. If you could feed them groundfood, (food off the ground in large sizes and amounts) they will probably do very well. You take it from there.

S: You can't guarantee that every drop of DDT hits that tree.

I: Oh no, that's right. There could be DDT anywhere else, including on the ground. What you think would be the most.

S: Maybe you could spray a tree in one area and not in another. Then collect specimens like grasshoppers, worms and things from both areas and examine them.

I: Okay. So you do this in an area where you can experiment with trees which have been sprayed. You examine the leaves, test the trees, and the soil underneath them. You find DDT present. In the area where trees weren't sprayed, you don't find any DDT--either on the leaves or in the soil.

S: If the DDT is present in one area, then it leads to the fact that all these animals have it in their environment. If the DDT is in the grass, then grasshoppers have eaten it. They would accumulate it somehow because they have to eat...if they eat so much of this they are going to get sick. The birds, if they eat grasshoppers and things, normally can't tell which ones have DDT so they come down and just pick them up. So I imagine that I'd like a wildlife place where they fence it off and keep count of birds which come and go.

I: A study area or enclosure of some kind?

S: I ought to set up something to see just how the birds are doing in both situations. I imagine the birds would die off at a more rapid...

I: Now you want me to give you some data from such a wildlife area in which you watch the population of birds. A group of trees--a stand of elm trees--has been sprayed and in an area a mile away you have a group of untreated trees in a fenced area with a population of birds. In the area where DDT was sprayed you find for several months nothing much happens. Some birds seem to get sick, but they recover. In the other area nothing happens. Finally, after several months, the robins begin to die in the area treated.

S: Maybe they finally got enough accumulated in their body.

I: How would you check?

S: I imagine an autopsy. I have to check first how much DDT is present in the area. It depends on how many sprayings you've made on that tree.

I: Let's go back. You have soil and foliage samples you took from the previous trees which you compared--sprayed and unsprayed. You know there is some DDT present in the soil; you know some is present on the trees after the spraying.

S: Well, you'd have to know how many sprayings. Do I have samples after each spraying?

I: You can know exactly how much is in the soil and any other parts of the environment you want to measure--grass, foliage, leaf litter under the tree, leaf moil. If there is any water flowing through the area you can have the residues and amounts in the water, whatever you feel is needed.

S: One thing you said was birds got sick; then they seemed all right. Well, after each spraying more accululates.

I: The customary procedure in say the spray program for Dutch elm disease is to spray at a limited time. I should clarify. The people who spray trees might tell you they spray when the beetles emerge from the trees. Bettles only emerge when adults to lay eggs in a short time--two or three weeks--which is the only time we have to kill the beetles. Then they don't spray again for 2 whole years. However, the DDT remains in the environment, although only one application is made.

S: DDT would be on the ground. If there is only one spraying, the rain would be washing it away. I would think the birds would eat the worms which would be the closest to taking it into their bodies. They are in the ground, and if the rain kept washing it in, then the worms would be about the only thing, though, that I could think.

I: Okay, we're going to stop. I would like to ask about our process. At the beginning was it clear what we wanted you fellows to do? Were you clear about how you were going to go at it by the time you finished reading or were you confused?

S: I was in pretty good shape. I thought he'll create a situation and whenever we have a question he'll create an answer and if we get stuck then I imagine he'll bring in more data and just help everything go along. Then everything would be under control.

I: Did you have any questions?

S: No, I just thought...take everything step by step, like chopping down a tree...one chop at a time. You know, keep chopping through like that.

I: Did you find yourselves going on different tracks at times?...were you thinking down a different avenue when on or the other was talking?

S: Oh yes, I found alot of the time I was getting ready to say something when he'd come in and I figured he's taking that, so I'll see if I can cut up on something else.

I: You explored somewhat divergent possibilities with each thruwing some light on the subject to determine the cause.

S: I learned one thing from playing sports--you don't fight your own teammate.

I: Do you think your questions were understood so that you get the answers most of the time?

S: I thought so.

I: Fine. Could you make any suggestions as to how we might handle it differently...how we might set it up or give you different information?

S: I think this thing had a lot of avenues to go down...to explore. I think if you were going to keep using this question it would be fine, but if you were going to change questions you would have to find one similar to this one because during an hour's period talking on the same subject, you must have an awful lot of things to talk about. And this one is pretty good.

S: It seemed to me there wasn't enough time. If you did it again you should have more time allotted to each person, or team, to explore this question, since there are so many avenues to take.

S: I was disappointed when you said we had to close because I was just kind of getting on something...

I: You were making real progress, you really were. It's undoubtedly true that it takes a lot of time. You were asked to cover a subject which has been under investigation for several years by numerous people and the questions you read with the type of data I fed back to you, almost precisely fit circumstances in which study has been made: two or three studies in Michigan and Illinois on consequence of bird die-offs from tree spraying. You were getting very close to the answer. It did turn out to be a food situation. It resulted from spraying, but it wasn't from the beetles. It resulted from the DDT on the leaves. When leaves fall in autumn they get into the soil, and earthworms feed on the leaves. The earthworms were found to contain large amounts of DDT. If you had gone into the birds' food habits you would have found robins are very avid earthworm eaters which forms a logical chain by which they receive DDT. But the chain requires a lapse of several months, including the fall months. It is one way the pesticides work. You are the only group who pursued the problem this way. In the other questioning sessions different types of answers were used. For instance, it wasn't a suburban area but an agricultural area. Questions led to a different types situations. With this general framework, there are several types of answers and no single one. We try to vary, in accordance with the students' questioning and

and for several different possibilities which can fit into the framework.

S: Is this something you had any concern about before? I'm not asking whether you investigated it; I just mean were you aware of pesticides on birds problem?

S: I have been wondering for a long time why so many dead birds are always lying on the streets because you always see them during the summer... they're just all over the place. A lot of times they just fall off the house...they just come right down, and that's all...mostly pigeons.

I: Pigeons are certainly susceptible to poison, but they are grain eaters, and they may well get it from the fields and feeding on grain and other sources. There are many different routes by which the birds get these, but the earthworm and the robin route is one particular one that has been worked out...one of the few which has been well described. Some of the others are much more direct.

S: I'm glad you explained the whole thing at the end because when you said the birds get sick but get better I was puzzled.

I: This is one reason we throw in complications because, as I understand my fuction in being here, I try to give you reasonably accurate and realistic answers within the limits of my knowledge. I don't know much about air and water pollution in Kansas City. I know something about the general problems so I tried to give you answers which are reasonably consistent with what you might expect and throw up something that might either put you off the lead or give you a definite clue as to where to go for information. To this extent, the information I gave you was reasonable accurate; although, some of it was hypothetical.

S: I think that if we had a few more minutes we could have found it, because we were almost there.

Interview Number 6

Interviewer: We would like you two to start talking your way through the problem, telling us what you would like to know and what you are thinking about.

Student: I'm thinking how man might be...have a lot to do with it...with the birds being dead...maybe insecticides, etc., and maybe just regular killing will--sports--hunting--you know.

S: Where are these birds usually found dead? Out in the forest, in the swamp area, in the city?

I: The birds found already have been reported to be mostly in the rural areas, either along the field borders or the fields, or along the edges of the woods; but, not deep in the woods. They are in agricultural areas; not many of them in the suburban, built-up parts of the city.

S: You say they are found in agricultural areas?

I: Not necessarily always in a field, maybe in the roadside trees, shrubbery, at the edge of the woods--or they might be in a field. They are not far from fields, in any case.

S: Are they any kind of field, or cultivated?

I: Cultivated fields.

S: What condition are the birds in when they have been found dead? Are there any bullet holes in them...like if a hunter would have shot them? What did they look like? Did they look like some harm happened to them?

I: If you would examine all these birds--there might be a sizable number--you would find no evident marks of damage...no broken wings...well, maybe a few broken wings or something, but no bullet holes. The only physical sign would be an occasional minor injury, as though they had perhaps collided with something and fallen to the ground. We might say 100 birds had been found, and not more than 10 percent were killed by physical injuries; either broken skin, broken bone, any sign of physical damage. The rest--90 out of 100--would be free of any marked damage.

S: How about something wrong with their heart or their inner parts? Would they show a damaged heart...like they didn't have the power to fly as high, or something like that?

I: An internal examination would be required. If you did examine some birds, you would find no evidence of heart damage or rupture of internal organs, as though from a heavy blow.

S: Has there been any trace of any poison in the bird's system?

I: How would you want to find this out?

S: See somehow if the bird...its food has been causing the death by poison or some thing.

I: You would want to have the bird analyzed then for some chemical poison?

S: Yes.

I: We analyzed the birds and found most of them--not all of them--but three-fourths of them, contained DDT, maybe five to ten parts per million. It's not a great or serious amount, but it's very widely spread. The chemist will tell you that it's common to find DDT in most samples of wild birds. He would tell you there are other unknown organic phosphate chemicals, which are pesticides, in some of the specimens, but he is unable to identify them. Apparently, they are unknown, shortlived chemicals which he didn't have adequate techniques to recognize. Some were in larger amounts than the DDT, but he cannot identify them.

S: Could they find anything wrong...like say the heat could have affected the birds, or something they might have eaten?

I: How would you find out about the heat?

S: I'd find the temperature in the area where the birds have been found in the past few weeks, or from whatever the average temperature was... whether it is high or low or just about normal. I'd look around to see all the different areas and how many birds died in each area and compare it to the amount of heat--the high temperature--and see if there is any effect.

I: We check the weather records and find it has been a normal summer with nothing unusual. It's not higher than the usual temperature for this time of year in two out of the five last years.

S: How about before that period?

I: Before that time, you can compare these with the average maximum daily temperatures in June for the past 75 years. The records for the last 10 years show some years are both a little above and below the average. There is not any consistent trend.

S: How about the water supply and rainfall and maybe humidity around that area?

I: A higher than normal rainfall occurred during those years; perhaps, on the average it has been a little wetter. There has been extensive flooding, but some gullying and quite a bit of run-off and washing off in the fields and ponds. They have been considered wet years and good for crop growing conditions.

S: I'd find the kind of food these birds usually eat; see if there is something inside this food that would affect their intestines or inner chemical systems.

I: Are you going to investigate this yourself, or are you taking your question to someone else, or looking it up in a book, or what?

S: I'd do two things. I'd look it up and see what it says in the book and look around the areas where these birds have died, and compare what it says in the book to what it...

I: When you go to a book would you look up birds or are you in a position to ask about different kinds of birds?

S: I'd look up that particular bird. Oh...well, I think you would have to know if it's just one kind of bird or birds in general.

I: There are several kinds of birds, but I'd say one of the most abundant is the morning dove, a bird that constitutes more than half the numbers picked up.

S: The morning dove? Then I'd try to find a book that goes into detail about the morning doves. I'd check its habitat, what it eats and everything.

I: Morning doves are mostly grain or seed eating birds. They are very abundant birds in agricultural areas because they are attracted to the seeds and weed seeds as well as grain seeds. They are also sometimes attracted to cattle feed lots and places like this. Their habitat would be open or semi-open country, but they do nest in trees, usually at the edges of woods, along roadsides or in thickets: places like Osage Orange are very good nesting sites for doves. They will nest in a thicket or low trees, then forage or feed over fields, around farmyards and wherever there is any waste or spillage of grain. They will sometimes feed on spilled food that has been put out for cattle in feedlots. They will go into the fields and feed right on the heads of grain sometime.

S: After that I'd go and look at the grain and the seeds. I'd see where they have crossed grain to see if something might have been in the grain that would affect morning doves.

I: Where would you do this?

S: I'd take that to a lab, wouldn't I?...To some expert or a lab?

I: What are you taking to the lab?

S: A seed...they usually eat grain and seeds.

I: Where are you going to get this seed?

S: I'd go take samples of different types of grain in the area.

I: You'd go out to an area where dead doves were actually found? Okay, you go out to this area and find in tracking this down...as a matter of fact, it is a very limited area where just certain crops have been treated rather heavily in the last few years. Quite a few birds have been killed, mostly morning doves. You get some of the grain from this area. It might be wheat, corn, milo...let's say that it's wheat. You have three different kinds of samples now.

S: Let me review. There has been no physical damage. Some DDT, but not a fatal amount and the grain growing has been rather abundant...no shortage. Do these doves ever eat insects?

I: Some, but not a great deal. They eat much less insect food than most other birds.

S: Any particular kind?

I: Common seed eating birds are the sparrows and we do see some sparrows, cardinals, among dead birds, but we don't generally find insect-eating birds. Mockingbirds and robins are not reported. Of the data, just by way of review, don't forget you have chemical analysis which, nevertheless, suggests some kind of short-lived insecticide is present in larger amounts than DDT, but it is not DDT, and it is something that the chemist is not familiar with.

S: There is something about this seed that keeps me with it. Like, you know how farmers cross the seed of wheat to make it better wheat and I think there would be some sort of chemical or something in the seed that would affect the bird.

I: What would you like to do with this?

S: With the wheat?...With the grain? I already took it under chemical analysis didn't I?

I: Okay, the chemical analysis shows none in the corn, but it shows some in the wheat and the milo. In this case it's the same suspected chemical insecticide that the chemist couldn't identify, but it is in much larger amounts. He says there is definitely a chemical here. It's an organic phosphate of some kind. I don't know which kind. It must be some kind of new material I'm not familiar with.

S: These morning doves, do they eat more of the wheat rather than the corn?

I: How would we find this out?

S: I think a way would probably be rope off an area or somehow try to isolate these birds with wheat, milo, and corn to see which one...

I: I think I've been a little negligent because you did postulate some autopsy, with considerable detail and examination of internal organs, did you not? And I didn't give you a full report because you should have had the stomach contents reported to you at that time. Lots of the doves had milo and wheat in their stomachs, but not corn.

S: I would take some morning doves and put a tag on them. You can do that, can't you? And feed them this wheat and milo, and see their reaction to it. Couldn't you just run a lab experiment on them?

I: In the laboratory or out in the field?

S: In the field.

I: You'd feed them and release them then?

S: Yes. Because you'd have other conditions then--wait--no you couldn't do that because that would be more than one variable factor. So you'd have to take it into the lab.

I: How would you go about doing that?

S: Well, you would have a certain number of the morning doves. You would feed them this...have we discovered whether this wheat and milo is a hybrid or just normal?

I: This is the same type of hybrid corn which is the standard high productive corn which has been for quite awhile in this part of the country.

S: For more than ten years?

I: I don't know what it's history is. It doesn't have anything unique to Jackson County or the particular area that you are working on.

S: I don't know how you would...what would be the control? Since this is hybrid they have been feeding on...do you know what the control might be? It would be so hard to keep the bird in a...

I: You can feed them on artificial feed of several kinds. Morning doves aren't too hard to maintain. Any book on morning doves would suggest some feeding diets which would maintain them--mainly several kinds of grain, if you wanted to keep them and not expose them to any chemical. I assume you are setting up a feeding test in the laboratory, but I'm not completely clear on what you are feeding these birds, or how many groups of birds you have. Let's carry it on.

S: I'd feed them wheat. I'd take, say 20 birds; 10 I'd feed wheat and milo, the rest I'd feed some other types of grain such as corn.

I: Say we can have clean corn from a feed supply place.

S: I'd feed them that...the other ten birds I'd divide them...I'd see the difference. I'd take tests of them to see if there is anything inside them that was different.

I: Was it ten birds you had on wheat and milo? What about the wheat and milo, did you give all the birds both wheat and milo?

S: I was thinking of taking maybe 21 and have big different groups controlled with this corn and then another group with wheat and another group with milo so we can separate this wheat and milo and see which one...

I: What about the sources of the wheat and milo? Where would you get this?

S: I would get this hybrid, or get the kind of corn or wheat or milo that was found in this area.

I: Get the same as that in the area? When you are out in the field you bring in some samples of wheat and milo to feed to the birds. Let's suppose after a few days two birds on the milo die and three more show tremors and unusual behavior. They can't stand up or control themselves but two or three are unaffected. Essentially the same thing happens on the wheat. They stay in perfectly good health on the corn.

S: Would the symptoms be anything like possible malnutrition?

I: Are you asking me as an authority or librarian? Morning doves wouldn't show tremors and bad coordination. They might get weak and in a stupor if they were starving, but this condition of tremors, shivering, convulsions indicates something is affecting the central nervous system which ends up in a paralysis. One would associate this with poisons.

S: I'd be led to believe I almost have the problem solved. Maybe I'm jumping, but it looks as if it is an organic phosphate inside the wheat and milo which does something to the morning doves--affects their nervous system.

S: I would be inclined to agree. I would take samples from their stomachs and run chemical tests to see how much of this chemical phosphate...

I: Find out how much it takes to kill the birds? This could be computed.

S: To see if it really was the phosphate that killed them?

S: We haven't identified what kind of organic phosphate this is?

I: No, we haven't. I've tried to match an actual situation as much as possible. It happens to be a material called azodrin on which you ordinarily can't get chemical residue determinations, although some chem-labs do. They have some information on it, but it's not something that is very persistent so it wouldn't remain very long.
Do you both feel you have found the answer to the problem?

S: I'd be pretty sure it was this wheat and milo, but I think I'd like to run or take chemical tests of a bird that just died to see if this phosphate is the only poison in the bird.

I: We've analyzed the birds which have died in the cage and they don't show any particular DDT. By this time you would have sought enough help to identify this. Yes, azodrin is present in these birds. The amount of azodrin might vary widely. If you get it fresh there could be a lot present, but some of the birds might not show very much at all.

S: We've established azodrin is causing the birds to die. Then it would really be up to (I don't know who it would be up to) to see if the grain could be changed. It all depends on how well the people care about the morning doves...if they want to keep the wildlife or if they want to keep on with the spraying.

I: Have you established why there's an increase in bird mortality?

S: Well, no, we haven't, except, maybe we could go back to the agricultural records to see how much production of wheat and milo has been coming. If there is a notable increase, and if the increase compares somewhat to the death rate, then I think we have already covered that the increase is due to the increase of this type of food over, for instance, corn. If the increase in wheat and milo production is related to the increase in death.

I: We can get the figures on the wheat, corn, and milo production, but they don't show any change. It is about the same each year for the last ten-fifteen years.

S: Have the morning doves been found in this area for the last ten years?

I: You could probably find out from the local ranchers; and they say, yes, we have some losses the last year or two, but they don't go back very long. We've only lost some in the last couple of years since we started using this new chemical. Before that we didn't notice any. Of course, you have evidently had some other causes.

S: I'd look at other birds, too. What other birds have there been losses in?

S: Robins.

S: I'd take them through the same laboratory test to see if their reaction is the same as the morning doves, if it is, then I'd let them go; let the normal birds go and see what happens to them. I would keep them from eating milo and wheat, and keep them in the same conditions. If they remained normal then I'd be led to believe that it is the azodrin.

I: Before we come to a close, perhaps I ought to give a little explanation on a little trick I played on you guys. My explanation I led you through doesn't fully answer this question. You got a partial answer, as much as I could give you, for the current year's dieoff, but what you were leading up to didn't really account for the whole trend. The situation didn't necessarily rate, but it simply was one example and if you had pursued the line you started with other chemicals and species you would have found other explanations for the preceding years, perhaps involving different chemicals. The change that occurred in azodrin was essentially just the last couple of years because it is a new chemical and has been a real troublemaker with birds. The early losses may well have been caused by parathion or something, as one would discover in the history of change and use of different pesticides on crops.

S: May I ask, is this azodrin a chemical or is it found in...

I: It's an organic phosphate chemical that is applied by spray from aircraft.

S. I was thinking that it was in the wheat.

I: No. It is a separate chemical sprayed for the purpose of killing insect pests which has been used only in the past two or three years and, in fact, in some of Arizona's irrigated lower valleys losses have been as high as 10,000 morning doves in one valley. It is not persistent; it doesn't last too long. The reason I put this in is because it is an example of a chemical for which your residue data is not very conclusive. Analytical data is hard to get even if you find a bird that's dead. It doesn't necessarily prove the birds weren't killed by the insecticide, but you boys pursued a number of other lines of investigation which led essentially to the solution of the problem even without the residue data as being a vital part. It is not quantitative evidence, but it's at least a clue.

I: Was the question relatively clear at the beginning?

S: Yes.

I: Something that we haven't explored before that I've been curious about. Were many of the terms, words, or phrases used unfamiliar ones?

S: The residue factor, does that mean after...

I: Means the amount--the trace amount--present in either the seed or the body tissues of the animal.

S: That's what I thought.

I: Has what we have been doing here sound like what you would do by yourself or other places when you are puzzling over a problem. Or is this a different experience for you?

S: I don't know. If we'd really go at it, I think I would think it over and wonder, maybe hope someone would think the same way I did, but I doubt if I would really explore it.

I: Is the problem and impact of pesticides on wildlife something you have been aware of before...is this a new idea?

S: No, it's very new.

S: I realized pesticides had an effect on the wildlife, but what I mostly realized was the effect of the polluted water on the fish you see lying on the beaches. This I had noticed; but not birds eating crops.

S: I have thought mostly about us...pollutants on apples, fruits and vegetables...we eat the outer skins...how will it effect us...and water pollution...just recently air pollution.

I: One reason I used a strictly unusual type chemical was I don't want you boys to think thousands of morning doves are dying all over the country. Steps are taken to prevent this from happening again. Registration procedures establish what chemicals can be used safely. The hazard to people, as far as apples and foods they eat, is much less than to wildlife because these foods are tested first. Foods usually have established safety levels. I am sure this has been done on azodrin already and that it is not considered a real problem for people. The trouble is we don't know enough about wild birds and animals nor their feeding habits. Sometimes they become exposed to chemicals through different foods and by different ways than are pertinent to human contamination. Where possible we try to avoid this, but it is a complicating procedure that requires many different kinds of studies. It takes time to develop this information.

I: Apples are subject to the tightest regulations. When apple trees are treated something extremely short-lived is used or they are treated quite a long time before harveting. The regulations will specify the minimum amount--a low-level of residue that can remain on the food, usually expressed in terms of parts per million. If it is a very toxic material, it may have what the government calls zero-tolerance, and will not tolerate any use. If it's a material that is not dangerous they may permit as much as seven to ten parts per million. Usually it's said that if a food has more than seven parts per million, then it must be kept off the market for a month or longer, depending on the decay time. We were feeding grouse on lettuce once that we bought on the market. The tolerance for lettuce for DDT was seven parts per million, but we didn't want any DDT in it because we were going to use it for feeding tests with DDT in the grouse. We found when we went to the market if we bought fresh head lettuce for human consumption we got almost zero, but if we took the culls--lettuce stripped off the outside of the head--which we were trying to do just for economy, we got about four parts per million, so we had to give up feeding them cull lettuce. This is one of the ways food is protected. If the lettuce has gotten some spray on it, you strip off the outer two or three leaves and eliminate it. There are a lot of these procedures, related to the way foods are processed, which have a definite protective value.

Of course, one thing, as far as the birds are concerned, is doves don't feed on corn very much unless it is waste corn which has been dropped on the ground during harvesting. They have to peck it out of the head, but the head is enclosed in the husk which protects the corn and is much less likely to have any pesticide residue in it; simply because of the way it grows in the husk. Where the head of the wheat and the milo is exposed to the air, it is also the kind of head birds can peck easily. There are some birds that will eat ears of corn, but not too many.

I: These morning doves showed a fair amount of wheat and milo that had been contaminated, but by the time the wheat or milo got to the bread this would be decomposed. It is a short-lived product and it hurts the birds because they eat it right in the field after the time it's been applied. As a matter of fact, you'd be in trouble with your chemical laboratory if you didn't bother to analyze those specimens right away. If you didn't analyze them right away, you might find any chemical, except a little bit of DDT. All of these complications are clues in one way or another, but unless one develops relationships you don't get any firm answer for your probing.

I: One other question I would like to ask is whether you have any comments or reactions to what we've been engaged in this morning? Maybe you do, maybe you don't.

S: I think it was pretty sharp!

I: You enjoyed it?

S: I enjoyed it quite a bit. I think you learn more this way than if somebody just told you everything without you having to think about it. I think you learn more this way.

I: That's interesting.

S: I must say that at some points it was pretty discouraging. We'd think we might have it and then you'd say, "No, that wasn't it," you know.

I: I think exploration of these different lines is fruitful, but in some cases must be discouraging because the judgment you have to make is whether the idea you have fits the evidence or not. You can't have several ideas and accept them all, so you have to have a basis for rejecting some. When you pursue a line of inquiry and you find some evidence doesn't fit what you're assuming, this isn't our own good procedure. Don't let it bother you, just reject it and say, "okay, this is leading to a dead end, where did I leave off?"...and go back and take up another line.

I: I was struck by you fellows writing notes. Some others wrote notes, but it seemed to me you referred to your notes, remembering things you had jotted down. As you think about all the things involved and you find out one is not involved, it has a discouraging effect alright, particularly if you've had a couple of clues suggesting the correct answer. You learn it's not correct, and learning this can be as valuable, in terms of the total task, as if you had learned it was.

I: As one thinks about how one goes about scientific investigations, you often come up against the mear impossibility of proving anything true. It is very difficult to prove something true, but it is often not too difficult to disprove it. When you have several ideas and you can disprove everything but one, this strongly reinforces your evidence that the one is right. It doesn't necessarily prove it's right, but the disproved information can be more definite than the positive information.

Chapter II

Interviews Regarding Food Preferences of Newly-Hatched Snakes

Each student was oriented to the purpose of the interviews by the interviewer as before. The nature of the phenomenon to be investigated was stated on a card, on which the following statements were typed; this was given to the interviewer.

Newly-hatched snakes of species x were found to seek one particular prey (worms) to eat, even though other kinds of small animals or insects might be closer to them. This same pattern of behavior was noted in species x snakes in three different areas in the United States at the same time of year.

The student was then asked, as before to indicate the way in which he would proceed to investigate the phenomenon of served in order to be able to explain it scientifically, using the consultant as a source of information or "data bank."

I: This is an interview on the topic of feeding preference in newly hatched snakes.

S: Okay. First of all, was this a particular species of snake?

I: Yes, this observation is based on one species of snake.

S: Okay. First of all, could the snakes see what you were feeding?

I: You're asking me now: can snakes see? Yes, snakes have fairly good vision insofar as movement is concerned, but many times a snake will crawl up past something that it might normally eat, but not see if the prey item is sitting still. For example, water snakes will feed on frogs; and a water snake can crawl within a few inches of a frog and not see it as, of course, the frog has concealing coloration, and sitting in the grass, if it doesn't move, the snake may never see it. But, once it moves, the snake will see it. They don't have the acute vision that birds have in this respect.

S: In other words, the object should be moving before the snake can see it, if it's standing still it can't see it.

I: Usually. Movement is not absolutely necessary but it certainly is important in attracting the snake's visual attention.

S: Okay.

I: As far as visual is concerned.

S: Does a snake hear? Like, if there was a cricket, could he hear the

cricket? Can a snake hear something?

I: A snake picks up vibrations. Sounds in the air are not particularly transmissible to a snake's auditory apparatus. But, if a snake were lying here on this table and you were drumming your fingers on the table, it would pick up these vibrations. On the other hand, if you had your fingers like this...and the snake couldn't see the movement of your fingers, it would like very little reception of any of these sound waves.

S: How does a snake eat?...worms or whatever he is eating?

I: Well, there are three different types of feeding mechanisms in snakes. One is just to grab the prey and swallow it; another is to grab the prey, wrap its body around it, constrict it and suffocate it; and the other is the injection of venom. Now, there are different kinds of snakes that utilize these different types of prey. Well, snakes that feed on earthworms are the type that just grab and swallow their prey alive.

S: If a snake, we'll say, is going after something like a frog, can he move fast enough to get the frog? Or, does the frog go faster than the snake?

I: Well, of course, this depends on the snake, and the kind of frog that....I think we can answer this question by saying that there are many, many kinds of snakes that feed on frogs;

and, in many places, snakes are the chief predators of many species of frogs. So, obviously, snakes...many times the snakes do catch and eat frogs.

S: Well, I didn't mean just only frogs but - like, are they fast-moving?

I: In general, yes.

S: Will a snake normally eat anything, or like...do different species of snakes eat different things? I mean, will a snake eat just about anything?

I: No. Each specie of snake has definite food items that occur in its diet with definite regularity. Now, there are some kinds of snakes that feed almost exclusively on one particular kind of food item, whether this be earthworms, slugs, crickets, fish, frogs, or what-have-you. There are other kinds that have a wide variety in their diet. For example, things like the bracers eat frogs, lizards, other snakes, mice, birds - just about anything they can catch. Whereas other species are very highly restricted in their diets.

S: Does the newly hatched snake eat different things than, say, a full-grown snake?

I: Again, this depends on the species of snake, but, in many cases, either the diet changes completely or the percentage of different

kinds of food changes with the increase in age and corresponding growth. For example, here is a draft of the change of food in copperheads. Notice, these are small snakes at this end of the scale, and large snakes here. But, notice in the small snakes - little narrow-mouthed toads and small snakes and shrews - as they get larger, a greater percentage of mice falls in the diet. This is one that is based on a study of some... I don't know... six hundred individuals. So, this is just one of many instances you can show like this, where the diet does change with size. Now, there are other species that start out and eat small food items when they are hatchlings, and continue eating the same type of food as adults. Generally, these are small species of snakes that do this. The large species of snakes have a very definite change in their diet, because obviously it takes a... it's a different kind of food than it takes to fill up a big snake than for a little one. In other words, a big boa constrictor that is fifteen inches long might eat some insects, but a fifteen-foot boa constrictor wouldn't bother eating an insect. It would sure take a lot of bugs to fill one up.

S: Does a snake, I mean in the sense of an appetite like a person where it's hungry, does a snake have an appetite just constantly?

That it could eat anything at any time. Or, does it...

I: Well, generally, they feed, and after feeding will almost be in a state of stupor, sometimes while digesting they will curl up and sleep it off. Now, snakes will generally feed irregularly - I mean, they don't eat three times a day or something like this. They...a water snake, for example, feeds on fish. They may come out of a small pool (and a drying-up stream is full of fish) and may eat eight or ten fish - every fish he can get down - and crawl somewhere and not eat again for a week. And, then, it might go out and is hungry and look around and can only find one fish, and that is all it eats. So, it is pretty much of a case of eating to capacity and digesting this and starting over again. Well, there you have got quite a lot of information on the feeding habits of snakes. And you have the observations that these newly hatched snakes feed only on earthworms. Now, can you set up some kind of a hypothesis about this?

S: One thing...that certain snakes eat certain things...have different appetites. That's all I can say. Ah...maybe the reason that these snakes didn't eat the frogs or the fish or everything is that they might not have seen them for one thing; and that the species that they were...they just weren't appetizing

to the snakes - the fish or whatever.

I: Well, now, you have involved two variables here. One, as you say, if it were not appetizing; and two, that they didn't see them. Well, now, can you set up some kind of experiment by which you can determine whether the sight of the prey was important to the small snake? You will now set up a hypothesis that the reason the newly hatched snakes do not feed on frogs and fish, or little crickets, is that they did not see the frogs or fish or crickets; they only saw the earthworms. Now, how can you prove or disprove this hypothesis?

S: If you had a snake and, well...say a frog, you could put them together first and, like you could make the frog jump or move or whatever, so that you would be sure that the snake has seen the frog; and, after seeing him, if he would eat him or if he would just....

I: I see, you would bring the baby snakes into the laboratory, set them up in cages, and give them different kinds of food to see what their reaction is. All right. Now, suppose that you did this and they only eat the earthworms. You could obviously see that the frogs may be with them...put their tongue out at them, or something like this, but not make any attempt to eat them.

S: Well, that would prove that the frogs, or whatever you had would be more appetizing to them...that they just had no desire to eat the frogs.

I: All right, that they have no desire to eat the frogs. Now, do you have any idea why? Is there any way...well, say, gee, that frog must not be good to eat; if the snake sees the frogs...why don't little snakes eat frogs? Is there anything that you can do here to try to answer this other than - I mean, you now have the observation that the little snakes will eat only earthworms. The only thing you can get them to eat are the earthworms. They seem to have absolutely no interest whatsoever in eating anything else but earthworms.

S: Well, you could then make a study on that species of snake that you have - do research on other studies that have been made on the species to see if they came out with the same results as you have - that he just has no desire to eat the frogs.

I: Well, all right, let us assume that you checked this out at the library and the only information you can find of all records from preserved specimens in museums, and so on that scientists have opened and looked in their tummies to see what they had been eating. They all had concluded they were only earthworms for both juveniles and adults. Or, let's take

another tack on this. If you go and look in the stomachs of adults or larger individuals of the same specie, that you find some frogs and maybe an occasional fish, maybe an occasional small mouse or something like that as well as some earthworms; but, in the juveniles, only earthworms. Now, you are armed with this information about the diet of the snakes, and we still have this bit of information here that baby snakes feed only on earthworms?

S: Maybe you could take....Say you had two baby snakes, and you could put them in a different environment in, like, maybe one would be...like close to the water or something; and put another one in another, and watch them grow to see if their habits will change from the environment they are in...if their food habits would change. If you put, like, one snake in with only earthworms; and you put another snake with only frogs - and you don't give them anything else; that is the only thing there is in there to eat - to see if that is the only food...if they eat the frogs, let's say, or if it was the only food they had, if they would eat it.

I: Now, this is an extra experiment you are trying to set up. You are going to starve these little beasties until they get what they want to eat. Well, I know some kinds of snakes

would do this; they would just sit in a corner and starve to death. Well, this doesn't give you information; even under the most adverse conditions, the snake doesn't want to eat anything but earthworms. Now, let me back up here a moment on something that you were talking about a moment ago though...and that is a change in environment. There has been a study done on food preferences of recently hatched snakes, recently born young, showing geographic variations in the food preferences of the young in the same species. And, this particular study concerned garter snakes and water snakes - two different species - from Massachusetts, from North Carolina, and from Florida. The individual doing this research showed that there is a difference in food preference of newly born snakes from Florida and those from Massachusetts. And this is within the same species. So, here the environment seemed to play some kind of an important role in the difference of availability of food items; there are different kinds of things to eat than there are in Massachusetts, and the snakes were taking advantage of these things present in the environment. Still, the recently hatched young had definite preferences. So, with this added bit of information, where can you go?

S: Well, permitting he does have different appetites and that environment can change it...so, I think it could just be that he just has certain appetites just like a human likes certain things.

I: All right. But, what...what's your favorite food?

S: Roast.

I: When you were one year old? Was that your favorite food?

S: I don't remember.

I: Or, when you were six weeks old?

S: No.

I: Well, how can it be your favorite food now? When it wasn't then? Is there some food that you like now that you didn't like this time last year, or two or three years ago?

S: You change as you get older, usually.

I: Why? Have you considered you have learned to like some kinds of foods that you didn't used to like?

S: Umm-hmm.

I: Has this baby snake had an opportunity to learn anything about food?

S: No. He hasn't had an opportunity to learn. For one thing he's just newly hatched, 2nd he doesn't seem to want to learn about anything. He just wants the earthworms.

I: Why do you suppose he wants the earthworm? I mean, put yourself in his position. It was your choice of food. There were other things around but you picked the earthworm for him to eat. Well, there must be some reason that the snake should have those poor, grubby, slimy little earthworms.

S: Well, could it be that an earthworm maybe resembles...you know... himself?

I: All right, maybe. So you now set up a hypothesis that small snakes eat earthworms because some feeling in Freudian psychosis here? That they will eat things of their own shape? Or, no matter what you want to call it, can you set up something to test this hypothesis?

S: No.

I: Well, I am sure you should be able to think of some design for an experiment. We are talking now about the shape of the earthworm being an important thing.

S: Well, not necessarily the shape but...well, the shape and the way he crawls across...like a snake crawls.

I: I suppose you have been fishing?

S: No.

I: Well, you have seen how they cut an earthworm in two or three pieces, haven't you?

S: Yes.

I: And, the tailend will flop all over the place?

S: Umm-hmm.

I: I suppose it happened that you cut earthworms into six pieces, or something, and let them drop in front of those snakes. A sixth of an earthworm....Does it kind of shoot the idea of shape and size?

S: Umm-hmm. But, then, you could....To test it is to see if the snake would still eat the earthworm, cut an earthworm and give it to the snake to see if he would....

I: Well, let's say you do this and he takes it down with great relish; he likes it and thinks it is a good idea.

S: Well, I guess that disproves that he...that it's not because of the shape.

I: What else might go on here? You say these snakes haven't learned about eating earthworms.

S: Hasn't learned about food. Not just earthworms, but any kind of food.

I: Well, what does this tell you? He hasn't worried about these things.

S: Well, maybe. It could be that he is going after what he thinks would be the easiest catch.

I: Do you suppose a little snake just coming out of a shell is thinking?

S: Well, I mean, he is going to get the easiest thing - like a frog that moves faster than a worm. Maybe he is going to get the slowest sure thing that he is going to get.

I: All right. Now, you present another variable - motion. Can you do that in an experiment to test this theory?

S: Well, you could put a snake in with, say, a frog and a worm... but then he'd be after the worm, and we'd be right back where we started from. You'd still have to figure out why he took the worm.

I: Well, say, if we fastened the frog down tight, you know, so it couldn't move, and then put a fine piece of string on the earthworm - or something to drag the earthworm across the table, and the frog would be fastened in one position. Could you do something like that?

S: Yeah...to see if he would eat the frog or go after the earthworm.

I: Now, let's say he sees the earthworm and chases the earthworm around the table and doesn't pay any attention to that frog sitting there.

S: Then, you are back where we started from.

I: Why do you like roast beef?

S: It tastes good.

I: That's why I like roast beef.

S: Maybe the worm tastes good to the snake and the frog doesn't.

I: All right. So, we are coming to taste. Obviously, we can set up something on taste again - in an experiment. But, suppose a snake never tasted an earthworm. How is he going to know what it tastes like?

S: I guess he doesn't....Can a snake...I don't know how to ask this. Well, like from the snake's mother...can he get like certain - what is it like? Can somehow with the food that the mother snake eats, can somehow the baby snake...?

I: Yes, if there is an inheritance of tastes and feeding habits.

S: Yeah, or like is there any way that the mother snake feeds the baby snake?

I: Well, mama snake lays the eggs and is gone. She never sees the baby.

S: Oh, well, okay.

I: Well, you have asked a good point here. In other words, is there any type of inheritance of feeding behavior? So, very definitely there is. In other words, what one generation of snakes will eat, the next generation of snakes will have the same habits. Possibly with minor modifications, with a change of environment or something...but we won't complicate things. Well, if this habit of eating earthworms is not learned, what must it be?

S: Test. Experiment. Test, when he is born, what it wants? He has to....

I: Well, you observe. The snake eats earthworms. Crawls out of the egg, you see, comes out of that egg over here and eats an earthworm. He has never seen anything to eat, has he? In his life. His life is only a few minutes old. So, he has come out and immediately eats earthworms. All of them do this. Even though they have opportunity to eat other things, they only eat earthworms. The first thing they ever bite ahold of is an earthworm, in every case.

S: Could there possibly be something in the earthworm that would attract the snake?

I: It is very possible. Now, we talked about the size and the speed and you kind of awhile ago gave reference to roast beef - the taste. What is it about this - you say "attracted" to use this term - why is an earthworm attractive? Why isn't the frog? Could you design some kind of an experiment by which you could test why the snake picks up different tastes, say for frogs and earthworms and fish and crickets? Or, do you think this would be worthwhile?

S: There is something about the earthworm that attracts him. You have to figure out what it is that attracts him, though.

I: Well, you have eliminated movement; you have eliminated the shape. So what you need to do is carry out everything until we get some kind of a positive reaction...well, I'll help you out on this...setting out different kinds of experiments. You can take extract of different kinds of animals. Like you use vanilla extract in cooking? You can centrifuge earthworms and, you know, water extracts that smells like earthworms and others...say, fish and frogs and so on. And some of these experiments that have been done with these little snakes. They take cotton swabs and dip them in these extracts and put the cloth in front of the little snake. And, a snake sticking out its tongue flicks and give them a period of time. Thus, indicating the more tongue flicking the more interest. And sometimes the snake will take the swab and swallow the cotton if it is their preferred food. You can do this same thing and see if the young snake eats only earthworms...that the only thing it will pay any attention to is the earthworm extract. You have eliminated so many things conceivable about an earthworm except its taste, or smell, which in this case is one and the same. The only thing it is interested in is that particular flavor. Just like the kid that you have taken to the Howard Johnson's ice cream shop and the only thing he wants is the

chocolate. They have these 28 flavors, but the only thing he wants is the chocolate. So that he has never had the opportunity to learn this, you can take a snake right out of the egg. It had never seen an earthworm or any kind of thing; he has never tasted an earthworm or anything else, but he will immediately go to the earthworm.

S: The snake's instinct? That it's just natural? Instinct?

I: Is this what you conclude? That it is instinctive?

S: Umm-hmm. That it is just his natural instinct...for earthworms.

I: Well, how can you prove that?

S: Well, just the proof that he goes straight to the earthworm. He has to have something that is making him go. Just his instinct that would make him go straight to the earthworm.

I: What if you set up the kind of experiments that would confuse the snake? What would happen, let's say, if you would dip the earthworm with crayfish extract and dip the small crayfish in earthworm extract?

S: Well, if he went straight to the fish that smelled of the earthworm, then that would prove that it was the taste of the earthworm that appeals to him. But, if he went right straight for the earthworm, then it would just be his instinct to go to the

earthworm.

I: Now, I don't know what happened in that last experiment, or if anyone has done this, but it seems that the sense of smell and taste are the thing, and this is something that is innate and born into the young snake...that they have these definite tast preferences upon being born, and will seek that item of food and nothing else...well, I think that covers things pretty well so this concludes the interview.

I: This is an interview on the problem concerning feeding preferences of the newly hatched snakes. Jan, will you start?

S: Okay. Well, first of all, I think I'd find out what kind of snakes they were.

I: And, how would you do this?

S: Well, I'd look up snakes.... First of all, in the encyclopedia. I guess I'd go through and probably pick out a couple that wouldn't cost too much. Then I think I'd observe them for the next steps, and then go back to the encyclopedia and look and see if I found the thing that looks somewhat like it.

I: All right. If you didn't get anywhere here, going to the encyclopedia, can you think of a more appropriate or pertinent source?

S: Possibly some kind of snake and what kind of food they eat. Maybe the snake...maybe they were testing the... eating of worms instead of crickets and frogs and fish.

I: Well, you're still in a situation of identifying a snake, right?

S: Yeah.

I: So, if you go to the encyclopedia and you don't get anywhere there, what would you do?

S: Possibly ask somebody who knew something more about it. Ask someone that had opinions on what they thought.

I: I see. You would seek some professional help from a person for identification of the snake. All right. Now that you know what kind of a snake it is, we are back to the problem. You have made these observations that all these newly hatched snakes eat earthworms but pay no attention to the crickets, frogs, or other food items.

S: Next, I think I would have an experiment and take one of the snakes and cut him open and see if their organisms inside are different from another kind of snake. Maybe they aren't able to eat crickets. Maybe they couldn't digest it, and that they take the worms instead.

I: All right. How would you go about this? You are saying that you have set up an experiment. Tell me more of your experiment. What are you going to do...what are you going to try to find out, so I can tell you what you will find.

S: I think, first of all, I'd feed the snakes two snacks, first one of them worms and then the other crickets; and see if the one with the crickets would digest it.

I: We are talking about this one particular kind of snake now. But this one particular kind of snake doesn't eat crickets. Based on your observation, he does not eat crickets.

S: Take the one, and feed it worms and then, possibly, wait and see if it digested it. And then, possibly, take it and

and cut it up and then see where...let's see...how their organisms inside of them differ. Possibly, their insides couldn't take it in compared like another snake. Maybe they could swallow it. Maybe their insides were bigger.

I: All right. To save you a few days' work here, by telling that you will find essentially no differences in the internal organs of the snake and other related snakes that have different food habits. That is, if we strike the kind that attack.

S: What should I do next?

I: Well, what kind of information do you need?

S: Do you know if this...like if he...after he got larger, if it was just because he was new born that he just ate the worms; or was it when he got bigger that he went ahead and ate the crickets and stuff? If it was just the young that....

I: Now, right there. Some species of snakes definitely change their feeding habits with age. As they grow larger, the type of food dictates changes. For example, copperheads will feed on small frogs and little snakes - ringnecked snakes and things like this when they are juvenile. And as they grow larger, their diet changes, so that by the time they are adults their diet is almost entirely of mice. On the other hand, there are some kinds of snakes that start off eating things,

small things - obviously small things when they are small snakes - start off eating things like earthworms, and the earthworms are what they eat their entire lives.

S: Possibly, he could check and see...possibly find another and see if they were just trying, or see if it was the same species and see what they would eat. Because then you could see if it was just the small ones, or if it was both.

I: How would you do this? Well, you can do this very nicely. You can pick up an adult and determine what the adults eat. But, what does this have to do necessarily with what the juveniles are eating? Recently, hatched young? You know now from your source that some kinds of snakes will change their diet with age as they grow larger, and other kinds eat the same things when they are adults as when they were juveniles. Now, this is a worthwhile bit of information; but, I don't think this is going to get you to the point we need to get here on your problem. Or maybe it will.

S: I can see your point. It might help because that may be the solution to your problem. Why they did act this way.

I: What might be the solution?

S: Maybe they just didn't have any taste for the crickets or anything like that. Maybe they just.... Maybe their mothers

just ate only the worms too; and possibly that's just why they ate it. And thenagain, it may not.... You know what I mean.

I: Right now, let's look at the situation more carefully here and, possibly pick up something you are missing. These are newly hatched snakes. A snake comes out of an eggshell, crawls across the ground, and over here it comes to an earthworm eighteen inches away, and he eats it. Another one comes out of the same clutch of eggs and goes over here somewhere and walks into a cricket, and he doesn't eat it. Another one goes over here and bumps into a frog and doesn't eat it. Another comes over here and bumps into an earthworm, and he does eat it. Now remember, these snakes are all from the same eggs and out of them just a matter of minutes. This is the first time they have ever fed in their lives. Their very first meal. So, look at it from this point of view now. The problem is this snake's being selective in eating its very first meal.

S: You said that they.... Like you said, one came out and bumped into the earthworm and ate it; another a cricket. Isn't it that snakes can't see very well? Isn't there something about that?

I: Well, snake vision is certainly not the best in the world. Certainly isn't that comparable with that of birds. But, they can see and they are inclined, however, to miss seeing possible

food items if the prey doesn't move. They are attracted by movement; their attention is attracted to movement. The snake would actually go toward movement, but a frog sitting in the grass here.... A snake known to eat frogs might pass within six inches of it, and if the frog didn't move the snake might not see it. As soon as the frog moves, the snake would very likely see it. But they can definitely see.

S: Could it be, possibly, that when the snake bumped into the earthworm it is shaped the same way.... Maybe he thought it was his own kind, but then again are you sure that the snake didn't even want to go after the cricket? You'd have to take that....

I: How would you check this? What could you do to see.... That is, if you go out in the field and observe several of these things; and you observe the little ones eating the worms, but you don't observe any eating any crickets. How do you know they don't eat crickets? Can you set up something, some kind of an experiment or cold observation of feeding here?

S: You could take, say, some snake and put it in one place with crickets, and all there would be in there would be crickets. And if they didn't touch them, then you'd know they didn't have any taste or anything, or maybe they just went for something shaped like themselves.

I: Yeah. You say that you would put a bunch of recently hatched snakes and give them a choice of crickets. All right. What do you conclude from this by seeing that these little snakes would just sit around and wouldn't eat at all? The crickets would hop around, but the snakes wouldn't eat the crickets?

S: Then you could say that there isn't any desire. And you could take another set and put them with just earthworms and see if they went after them or not. And if they did, then you could form some kind of a hypothesis.

I: Now, you are having a definitely controlled observation here, at least partially controlled: giving a choice of earthworms or nothing to eat, or giving a choice of crickets or nothing to eat. Can you carry this further?

S: Maybe you could take both earthworms and crickets and put eggs, the nest...before they are born, and when they hatch they could come out and see whichever they go for.

I: All right now, let's assume here they only go for the earthworms. You have ten snake hatchlings, and you get ten earthworms and ten crickets, and you end up with ten crickets and ten snake hatchlings and all the earthworms have been eaten.

S: Then you could say that...you could just say they didn't have

any desire for the crickets and they just went after some shape of their own. You could put...not earthworms again. You could take another experiment and put a different kind of worm and cricket just to see if they just went after the earthworm or just any worm. And then you could say they inherited a desire for the worms. There would have to be some reason why not.

I: All right. So, you have mentioned two things - the shape and the taste. Let's look at the first one here and design some kind of an experiment to test this business of whether it's the actual shape of the food item.

S: Well, you know, to go fishing with the plastic worms, possibly put them in there, and see if they went after them...for the shape. And then, cut that one out. Because if they did go after it, it was the shape of it. Because they are the same shape.

I: All right. Just on the basis of your probably very limited experience with plastic worms and snakes, do you suppose the snakes would eat the plastic worms?

S: Well, if it were the shape, I think they would attempt it.

I: You think they would go and at least take a close look at it. All right.

S: Then you could find if it was the shape.

I: I'll tell you what I am pretty sure will happen in this situation. You went down to the store and bought some plastic fishing worms, and the snake would come over and nose around it and crawl away. I would be very, very surprised if they attempted to eat it. That's another experiment down the drain. But, you are eliminating possibilities as you go along.

S: Then, you could take maybe an earthworm and cut it and put it in there and see.... Then you could also tell if it was just the shape, or if it was the smell. Because you said that the earthworm wouldn't be the same shape as the plastic one. You said they would crawl around it. But you put a live one in there; it was smaller, that you'd cut up, and maybe if it went after it.... You have to eliminate the shape because it didn't go after the plastic. Then you could tell if it was the smell or taste if it even went near it.

I: All right. So, you would take an earthworm and cut it up so the pieces no longer resemble an earthworm. All right, you do this; and let's say now you conduct this experiment and the little snake noses around the pieces, and the little pieces would just be wiggling and the snake immediately starts eating.

S: That would cross out shape entirely.

I: I think you are doing very nicely. You are eliminating shape.

And you have eliminated crickets because they won't eat crickets. And now, they won't eat fake worms, but they will eat parts of real worms that aren't shaped like entire worms.

S: Then you could create another experiment. Take two different hatched snakes and put one in one place and one in the other, and put a piece of earthworm in one and put a different kind of a worm (I can't think of any), but then you could tell if it was that certain kind...it was the smell of it, possibly. Because if this snake went after....

I: Well, I think before you can go with this experiment you need some additional information. You are proceeding very nicely, but you have the cart in front of the horse here. Something that you should ask and to save time and undue deliberation here...we have the problem of can the snake smell?

S: Can they? I know nothing about snakes.

I: Well, this is good because if you knew a lot about snakes your answers and discussion here would not be comparable with those of other people. Well, you say, "Can snakes smell?" Snakes can smell in a way that's somewhat different from what we know when we think of smelling. But you see snakes with tongue flicking all over. The tongue is a sensory organ, and the tongue is retracked into the mouth and little tips are

are stuck up in a special structure in the roof of the mouth called "Jacobson's Organ" and this receives the sensations of smell and taste. So, it is kind of a combination eye, nerves and taste buds.

S: Well, that could also... cause them to not eat crickets, because you said that they can smell. It would smell the cricket and have no desire for it because the smell and taste....Maybe it wouldn't.. didn't like the way it tasted; and then tried the earthworm and it appealed to their taste.

I: All right. So, you are saying now that...well, that you have hypothesized that the young snakes distinguish their food on the basis of taste or smell or flicking the tongue out around, but not actually taking a bite of the animal, but of sensation. All right. This is an interesting hypothesis. Now, can you design an experiment to prove or disprove it?

S: You could, in a way, take a part of a cricket and put it in with one snake and see if it went after it or not. Then in another, put a part of a worm. This would prove...because if it didn't like it, then you could form some conclusion that taste did have to do with it.

I: Well, at least that partial bits....You're proceeding with evidence very nicely, but can you somehow get the idea of

designing an experiment in which you are testing the tasting abilities, or smelling abilities of this snake, or earthworm, on frogs, crickets, and so on, without having the actual prey-item involved? Without the frog actually being there, or the earthworm being there? In other words, you are going to attempt testing for taste, and the only way that you can really test for taste is to deposit the taste...is to eliminate other possibilities, such as visual, structural or size - which you have eliminated these things as you have gone along here. And, now we are down to this very nebulous sense of taste and smell.

S: Well, maybe you could try some kind of an experiment on the snake itself. But, didn't you say that the structure and organs are the very same?

I: I think in the instances here you can consider them identical.

S: Well, that would cross off that one then. We could possibly go back to the encyclopedia. Ah, or ask someone if there is any other kind of bug that smells the same as a cricket, but is not shaped the same way as a frog - but has the same smell and that way might prove their smell. Because if they didn't go to them, that could in a way....

I: Well, of course, you already know that the snake has an interest

in an earthworm.

S: Yeah. I don't know what I would do next then.

I: Well, may I offer a suggestion now that you are down to the taste business here? You have worked your way very logically to that point. Now you are hitting a stumbling block. Do you have any suggestions of how you can disassociate taste of the animal, or the actual animal insofar as the snake is concerned? How can you give it a taste of the cricket without its actually seeing or touching a cricket, or give it a taste of an earthworm or smell of an earthworm without its actually seeing an earthworm or touching one?

S: Well, you can maybe use some blood of one, you know, possibly....

I: Now, how would you do this? This is interesting.

S: Well, you could take a snake, you know, they are real slimy?

I: You're talking about a worm.

S: Yeah. They have a lot of blood - juice, you know. And I guess you could cut one open and then take some of the juice and put it in front of a snake, and see if it went at it.

I: Are you just going to put a couple of drops of juice out here, or put it on some chewing gum, or what?

S: How about if you could put it on the snake's tongue?

I: No, because that would be kind of cheating on the snake, now wouldn't it? The indication is that if he comes over and

flicks his tongue at this and shows his interest in it, then this would be a desirable. Or if he comes over and flicks his tongue at it once and turned around and went the other way, this would be an undesirable food item. Well, you have worked this out very nicely up to this point because this is exactly the kind of work that has been done. You take earthworms and homogenize them - put some earthworms and water in a blender and you end up with extract of earthworm. Then you can do the same thing and get extract of frog, and extract of crickets, extract of fish. Then take cotton swabs and set them up with the different ones and watch the interest the snake will show. And, in this particular case the snakes saw interest only in the earthworm extract. Now, you can eliminate everything except the smell. Now, let's go back and concentrate on this aspect of these newly hatched eggs. They come out of the egg and only eat earthworms. Now, you know that they eat earthworms and, through your investigation, you know that they eat earthworms instead of other critters because this is the thing; the scent of the earthworm is what they are attracted to and they are disinterested in other scents. Now, we come to the question. Why do baby snakes eat earthworms and nothing else? What conclusions can you draw?

S: I have formed the conclusion that in a way they go after the shape of them, but mostly it is the taste of them or the smell.

I: Well, why do they do this? What makes them do this? You have developed this very nicely now, let's use the old grey-matter. All right, we have two. What was your first meal?

S: I don't know. Milk, I guess.

I: What?

S: I guess what they fed me.

I: Suppose now that you, as a new born infant, have coice of a bottle with milk in it or Coca Cola in it.

S: I'd probably go after the milk.

I: Why?

S: The taste, I guess.

I: Do you like roast beef?

S: Umm-hmm.

I: Do you like raw fish?

S: No.

I: Why is it, do you suppose, that you like roast beef and don't like raw fish?

S: The taste of it, and I don't think I could sit there and eat a piece of raw fish.

I: If you were an Eskimo, do you suppose the feeling would be the same?

S: I think I would eat the raw fish instead of the roast beef.

I: All right. Now, had you been born here in Kansas City here, but at a very tender young age, were transported to the Arctic and raised as an Eskimo, which do you think you would prefer today - raw fish or roast beef?

S: Even if I was little, you mean?

I: Umm-hmm.

S: Well, that would, I guess, in a way depend on how old you'd be.

I: Very, very little.

S: Still an infant?

I: Umm-hmm.

S: I think you'd eat the raw fish, because that's what would be common to everybody else.

I: So, here in this case, you are learning to eat certain things because of your environment.

S: Yeah.

I: And you develop a taste for things. Right now, there are things that you enjoy eating and that five years ago you didn't like.

S: Yeah.

I: Your mother probably harped at you, you know, "You ought to eat these things. And one day you decide, Gee, that's really good after all." Okay. See you learn these things.

S: Yeah.

I: All right, let's go back to the snakes.

S: The thing is the snake...he's never hatched....

I: This is the very, very important part of it.

S: That's what makes it, because he doesn't have time to assume a taste. I mean....

I: He hasn't had any opportunity to learn.

S: ...to taste anything else.

I: So, why does he show this preference? And, obviously, he does. He has tested it and tested it and tested it; and every one of these little snakes has shown this food preference. And, yet, this is something they could not have learned.

S: I know what you mean, but I don't know how to say it. Like kids today, you see, some like carrots, squash, and other kids won't touch them. Like the baby food for a child. They spit it right out.

I: Yeah, but this is...we are into the point though. By the time the kid is doing this.... Like the first association with eating carrots there's an unpleasant association, something that scared him the first ime he ever ate a carrot that really had no association with the carrot, but he, in his mind, associates being scared with eating carrots and, therefore, never liked to eat them. But, here we have nothing like this. We

are at the extreme basic thing - first meal.

S: I suppose the snake had....Has the snake ever had any association with its mother?

I: Mamma lays the eggs and goes on her way. If she ever sees them, it is purely accidental.

S: Is it something to do with the egg?

I: Is it what?

S: Is it something to do with the egg?

I: Ah, no, I don't think so. Well, we are talking here, are we not, about feeding behavior?

S: Yeah.

I: What kinds of behaviors are there?

S: I don't know what you mean by that.

I: Well, we have already talked about one kind, and this is,you learn.

S: Yeah.

I: Now, is there any other kind of behavior?

S: You mean the kinds that you learn to eat?

I: Yes. Well, we have talked about those. Are there other kinds of behavior? Other than things that you learn? I mean, you learn how to do a certain kind of dance. You learn how to speak a certain kind of language. You learn certain customs of behavior from your environment, and with those with whom

you are associated, and so on. Now, are there behavior patterns that are not learned?

S: Instinct. Would that be?

I: Now, you say instinct. What's instinct?

S: Like a dog has instinct. He knows to come out of the rain when it's raining. Its self grasps an idea that it is raining and to come out of it.

I: All right. Do you think that instinct could apply here?

S: Possibly, because....Does a snake have instinct? That you know of?

I: Well, instinct is more of the human behavior term than is used with animals. You talk about innate behavior, that which is born in the animal.

S: Well, that could be.

I: All right. You say that. What kind of a conclusion would you care to draw from these observations - the library research you have done and the experiments you have carried on in the laboratory?

S: I would say it is instinct because it didn't go for the shape. That shape had nothing to do with it. It was the taste and the smell. You put the taste...and it went for the worm. I don't know what kind of an experiment you could find to prove it, but....

I: Well, I think you have already in the fact that if you take your

young snakes and give them their first meal they always go to the earthworm. They have never had any learning in their feeding habits at all. This is their first meal, their first attempt.

S: You could say it is instinct because all the other snakes have done it of the same species?

I: Umm-hmm.

S: Then, it would just be natural. Say there were two snakes. Say there were five snakes, and two snakes went for the earthworm and the others went for the crickets, but they didn't touch them. But the other two did, and they ate them. Or, you could take another group of snakes, say two or three more generations, and they did the same thing. Then you could form if it was instinct or not. You could take the snake and, say there were five more, and if three went to the earthworms and two went to the crickets and didn't eat them.

I: What other thing could you possibly tack on here? To test? You could attempt to teach. Let us say that you took earthworm extract and put it on the crickets.

S: Yeah.

I: And slowly, I mean by giving a group of snakes earthworm extract-covered crickets, and slowly removed the amount of extract on the crickets over a period of time until you

get them to eating plain old-fashioned crickets. It is possible that you could train a snake from just learning. He has changed his taste from earthworms to crickets. But then the next thing of interest, of course,, would be to take the offspring of such parents and subject them to different flavored cotton swabs.

S: And see what they go to?

I: Is there any question in your mind as to which one they would take?

S: No.

I: Which one would they take?

S: The earthworm, I think.

I: You are right. Okay Jan. I think that will do us.

First problem is making up tests to determine if hypothesis was correct.

Conclusion: The snakes ate worms because of instincts and the size of the snake i.e., they changed their diet as they grew older eating more than earthworms, going to larger foods - frogs etc.

They ate earthworms because they were babies, reasons for conclusion:

1) Frogs too big to be eaten by little (smaller) snakes.

2) Graphs that Dr. Duellman had

3) Library reference, telling what they ate, structure of mouth at different ages, reasons given for eating earthworms, feeding habits; she would look for the answers in Natural Science Magazines, Encyclopedia.

Structure of Testing Hypothesis:

Pick a region which you could control the food and put a few snakes in, then watch them. Seeing what they would eat when worms, crickets and frogs were introduced. Use different age group snakes, all same kind, one put in at a time, being careful to not allow one snake to eat all of one kind of food.

Put one snake in at a time and see what it ate. Some person could (would have to) watch but not disturb the snakes.

Season could make a different seasons and how old they were.

Graph the age of each snake and what it ate for each season. See when they ate the earthworms and how this was dependent upon when that were born, thereby determining age and the amount of earthworms gone.

I: All right, You're here at Bishop Hogan high school and you've just read a statement of the problem about newly hatched snakes. They were observed to emerge from their shells, move about, and selectively feed on some kind of food. Now this is a problem for you to solve, and I am here to act as your resource material. You may ask me any kind of specific questions, but not a general type of question. Do you understand what I mean? Where do you want to begin on this?

S: You mean like ask a question?

I: Well, say you have just been on these 15 field trips and made these observations. Now, do any kind of questions come to your mind on the basis of these observations you made?

S: The questions would be how come they didn't eat the crickets and everything. They just ate the worms, so you could find out what kind of worms they were.

I: All right, I presume here we are talking about earthworms. Now tell me if you had a choice, which would you rather eat, a cricket or an earthworm?

S: It would be the cricket I think.

I: Well, obviously the snake did the same, didn't he?

S: No he didn't eat the cricket, he ate the worm.

I: All right now, we have a situation here of newly hatched snakes who have never seen anything to eat before, now all the observations indicate that they ate the earthworms and not the cricket. Do you suppose there is some reason for this. Is it just by chance?

S: Well, maybe its parents, they all lived on earthworms so they had an instinct to eat the earthworms.

I: They have an instinct. All right, so something has been born with them, this aspect of their eating behavior.

S: I think it would have to be unless maybe....No that wouldn't be right, I think it has to be born in them.

I: Well, would they have any chance to learn this?

S: You mean to learn what to eat?

I: Yes.

S: Well, right after they were hatched they were, well, they wouldn't have the time to learn it if they ate it right after they were hatched.

I: All right you're saying now that the little snake never had an opportunity to learn to select one food item over another.

S: Not unless it's by instinct.

I: Well, instinct is one thing and learning is something else. Now, in these observations did the snakes encounter any other kinds of food?

S: Yes, they saw some crickets and frogs and fish, but they didn't eat them.

I: Well now, let's suppose that these little snakes are a foot long when they're born. Do you suppose this might have anything to do with the kind of things they eat?

S: Maybe.

I: Do you suppose they could eat a frog that's four inches long?

S: No, they would probably pick the worms because they were long and the worms could fit in, but the frog would be too big.

I: All right now, does the problem of size of the food item and the size of the snake present any kinds of ideas to you of problems involved in these observations?

S: You mean would the size affect what they ate?

I: Well, obviously the snake cannot eat something bigger than it is, right?

S: Well, that wouldn't be the answer that they didn't eat the others because they were bigger.

I: I don't know. You're asking me to answer the question for you. All right, so I just brought up this point here wondering whether or not the selectivity of the food depended upon, as you say, the instinctive behavior, or is the feeding behavior dependent upon the size of the food item?

S: You want me to pick one of those?

I: Well, it might be one of either of these. Now can you think of some way to test this so that you could determine for sure that it is either the size or the actual food item that the snake is selecting?

S: Well, you could get snakes of different sizes, different lengths. I mean they don't all have to be a foot long, and well, I know they're still thicker; they'll eat a frog. Well, test all the snakes, and all of them ate the worms. It was just on this one reservation that they did this.

I: Yes.

S: Well, could you compare them with other snakes that weren't on the reservation and see what they did. Maybe being on the reservation changed them. Maybe it would have something to do with that reservation if they acted different from the other snakes.

I: All right. Do you know the garter snakes you find around Kansas City, the little black snake with the yellow stripes on it? All right, let's take the species of garter snake we have here and put them all over the eastern United States, from Canada to Florida. Now would you suppose that the garter snakes in Canada or New England have the same feeding habits as those living in Florida?

S: No, because we have different foods to feed on. Maybe like crickets are real abundant in parts; the snakes would eat the crickets. They'd just eat what was around their environment.

I: All right, now take this long spread from New England to Florida as an extreme to illustrate a point which creates another problem. We're talking about grounds on one reservation. Well, let's look off the reservation to see what the snakes do. But here you're introducing another variable because you're moving into a different population, and perhaps into a different environment. So you have the environmental changes as another variable. Instead of possibly solving the problem, you might be creating a bigger problem. Our problem now is to determine whether these baby snakes feed on selected prey items because of, as you say, their instinctive behavior or because of the selectivity in size of the food items--that they are only capable of eating things of a certain size.

S: Well would you have to pick one of them and just it, and test it and see if it works?

I: Well, that's one way of doing it. Would it help if you devise an experiment to do this?

S: Well if you pick the one that....Well you couldn't find their parents.... Well, maybe if you took some snakes and marked them and put them in the reservation you could see what they ate on. Then their snakes... you could see if it just grew, if it was instinct.

I: Now you're going to take some adult snakes and mark them?

S: Well if you took some snakes....Well, would that be changing the environment if you took, like some snakes from things that weren't on the reservation and they didn't eat the worm. When these snakes grow up, do they just eat worms or did they eat crickets or anything?

I: Now you've come to one aspect of the problem. How would you go about finding out what the adult snakes ate?

S: You'd keep track of the snake and see why they know. Like if at first, when it was born it just ate earthworms, and then when it grew older it ate crickets. See if they all ate earthworms all the time, or if they changed.

I: Would you believe that? Without any specific information on this, would you believe that the diets of snakes change with age, which of course is indicative of the change in size, older snakes being bigger than younger snakes?

S: I think it would change as they grew older. I don't think they would eat earthworms all the time, all their life. I mean they'd eat other things when they got older.

I: Well actually, this is the situation in a great many kinds of snakes....For example, in copperheads...your familiar with the copperhead; you know what it is. Look at this table, this being different kinds of food items as compared to the length of the copperhead. Can you see that the large snake, the adult snakes eat largely mice and moles or small rodents; whereas the young snakes tend to eat little frogs and little worms. So here is a very good example of a dietary change with age.

S: Well then you'd just keep track of...you'd find out why these snake... well maybe they eat earthworms, just like those little snakes ate worms, and small toads. Then you could just keep track of what they ate.

I: All right now, do you think this would be a reasonable field exercise-- to go out and follow a bunch of snakes and watch what they ate.

S: You mean would it be useful?

I: No, would it be feasible? Have you ever gone out snake watching?

S: No, but if you're a scientist.

I: Well, let's put you in the scientist's shoes. We have this reservation of 5000 acres of land in which there are innumerable snakes crawling around in the woods and grass. You're now concerned, are you not, with trying to determine what these snakes eat, the adults as well as the babies?

S: Well you know that there's things that change in the diet as it grows older.

I: How do you know?

S: Well, not all snakes are like those copperhead snakes.

I: No, not all of them are.

S: They don't all have change in size as they grow older.

I: We know many that do, and some that don't, and for gread many kinds of snakes we don't know this information about at all.

S: Well maybe you'd look up and read about these snakes.

I; All right, now let us presume that you have gone to the library and you find a resource of material, which in this particular case is me, and you have drawn blank.

S: You mean it can't tell you anything.

I: Yes. There's a general statement in a book that says these snakes are known to feed on earthworms, but it doesn't give you a nice table of the results of investigations of five or six or seven hundred individuals showing what percentage had eaten earthworm or what percent had eaten mice or something like this.

S: Well, if you can't find anything you could get books on snakes. If you can't find anything in the books about the snakes....

I: Now let's presume that you can find nothing more than this one statement: that these snakes and this species of snake is known to eat earthworms and that is all the facts.

S: Nobody knows why.

I: Now you're really interested in this. You want to know why these things eat earthworms or if they do eat anything other than earthworms. How would you go about carrying on an experiment here?

S: Make you own chart.

General structure of inquiry interview is to determine if hypothesis was correct. The snakes ate worms because of instincts and the size of the snake i.e., they changed their diet as they grew older eating more than earthworms, going to larger foods--frogs etc.

They ate earthworms because they were babies: reasons for conclusions:

1) Frogs too big to be eaten by little (smaller) snakes
2) Graphs that Dr. Duellman had
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Testing Hypothesis:

Pick a region which you could control the food and put a few snakes in, then watch them. Seeing what they would eat when worms, crickets and frogs were introduced. Use different age group snakes--all same kind--one put in cage at a time, being careful to not allow one snake to eat all of one kind of food. Put one snake in at a time and see what it ate. Some person could (would have to) watch but not distrub the snakes. Season could make a difference: extend the time period to 1 year and see what they ate at different seasons and how old they were.

Graph the age of each snake and what it ate for each season. See when they ate the earthworms and how this was dependent upon when they were born, thereby determining age and the amount of earthworms gone.

I: This is an interview on the subject of feeding of newly-hatched snakes. Well, go ahead.

S: First of all, I would acquire a snake. You know, a newly-born snake. And I would take and get different insects--crickets, frogs and fish and worms--and see which one of these he would eat. Then on, say, the ones that he didn't attempt to eat, I wouldn't draw my conclusion. I would try different kinds of snakes--different types of frogs, crickets--and then, after doing that, I would go to the library and get some information on what type of food different snakes fed on. And then I would set up my major experiment.

I: If I may interrupt you, I think you need to get this information before you set up your experiments. What kind of information are you after? You have to have the information now.

S: The kind of information I would want would be what type of insects inhabit around where certain snakes live, what different types of snakes like and feed on, and what different size insects, frogs, and fish, can snakes overtake.

I: All right. Should I provide you with the answers for these things?

S: Yes.

I: All right. We can take some snakes which feed only on earthworms. Other snakes feed almost exclusively on crickets. Other kinds of snakes feed, maybe, on crickets and other kinds of insects--earthworms, and so on--when they are small. But, as they grow up and become larger, their foods change until maybe as adults they eat almost exclusively rats and mice. Now, you had another....

Oh, again there are some kinds of snakes that feed almost exclusively on frogs, but obviously, the juvenile can eat only the smaller frogs, whereas the large adults can eat big ones. Does that provide you with a sufficient amount of information on food habits?

S: Then, after that I'd take certain snakes that I was testing and, you know, find out if they were active snakes or mostly just lay around, you know, the type that eat a lot to keep up. And then I would ...I'd have to find out this, you know, what type of snakes wanted because that would have a lot to do with their eating habits and what they ate, because....Then I'd....

I: Well Bill, one thing I might mention to help you from going too far astray that these observations can be assumed to be all of one kind of snake. This is one species of snake we are talking about. So really you only have to be concerned with learning about the food habits of this one particular kind of snake.

S: All right. So I'd go to the library and find what kind of snake I was studying. Then I'd find his food habits.

I: All right. You have now found the name of this particular snake, and the only thing that is known about it's food habits is that it eats earthworms.

S: I found this out. Then I would find an older snake of the same species and test it against...you know, if it ate frogs, fish or crickets. And if this happened, then I would draw the hypothesis, you know, that the larger snake ate different types of food while the young didn't. I would take a frog and small fish and cut them up in smaller sections so the young snake would have a, you know, overtake them and eat them. If this happened that the young snake

did this, then I would draw the hypothesis that the young snake didn't eat these things because the frog and the fish would get away, and the crickets also would get away from him. The worms were the only thing that he could catch up with to eat.

I: All right. That's a very good experiment. So let's say you did this. But I think there is one thing you also need to do to be fair here in your experiment. That is to say, you are killing crickets--maybe taking the jumping legs off. You're cutting up fish into small pieces, and using frogs, cutting the legs off--and you have essentially the same little masses of food items. But you still have a live worm. To be fair, you need to kill the worm too, so that it isn't necessarily movement involved here that attracted the snake. Now, if you set up such an experiment as this, you would find that the snales would eat the earthworms and not the others. I shocked you now, didn't I? Well, as the old saying goes, if you don't succeed at first, try again. This is a stubborn little snake.

S: Then, if it still ate the worms after that, I would figure...instead of being just a trick--the size and everything--I guess I would draw the conclusion that he had had trait passed on. But, I don't think that would be...

I: I didn't hear exactly what you said.

S: I think he would be eating worms because of heredity.

I: All right.

S: Is that possible?

I: Well, I think it might be possible. But what are you going to do to prove it?

S: To prove this, I would...

I: Before you get too involved on this, let's back up here a moment and look at something else. We are recalling now that these little snakes are just coming out of the egg. This is the first meal. First bit of food. First thing they have ever seen to eat, and the only thing that they eat are earthworms. So, you have eliminated--by your first experiment here--you have eliminated the size business and also the agility of the potential prey from escaping. So, now you are...I think...why don't you try following this line of attack here?

S: All right. If it wasn't because of the size of the worms, fish, and the grogs, then I would draw an hypothesis that it was fragrance and....

I: Now you need some more information.

S: Now I need some more information so...I'd have to know if the snake was able to have a sense of smell. If the crickets and frogs did vary that much.

I: All right. Snakes do have a sense of smell in that - you see snakes flick their tongues out. This is a sense organ. When the tongue is retracted back into the mouth and pushed up into the specialized structure into the roof of the mouth called "Jacobson's Organ," and from this it derives a sense of smell and taste. Now, a snake may pick up smell in the air or taste by touching its tongue against things.

S: And would the fragrance between the worms and the frogs and the crickets have that much of a variance to be able to be picked up by a young snake?

I: Well, we could make an assumption that they do have differences, but I think we need to have an experiment to test this.

S: Yeah. Let's see. Young snakes. Now, if I set up an experiment like that, I'd take the worm--same mass of worms and same mass of fish and, again, you know, kill them so there wouldn't be any deal about moving. Then I would...what I would want to do is be able to make the smell of all of them the same or take the smell away. You know, like when you refreshen a room or something like that. I don't know how I'd go about that. Make them all smell the same, dipping them in a solution or something like this, and....

I: All right. So, let's see about whether you can dip them into something...oh, some artificial flavoring. Dip them all in chocolate syrup.

S: Yeah.

I: I would say that if you did this, the snake would not eat them up.

S: Then, I....What if he didn't eat any of them. There would be two things that I could prabably draw from that. The first one would be that he does have a sense of smell for the worms. And, the second one would be that he doesn't like the chocolate. Than, there would also be another hypothesis besides the smell. It would be because of the taste.

I: I think...or let's just say here you can consider smell and taste being all the same.

S: All the same?

I: Yeah.

S: All right. Set up an experiment. I'd get different types of worms, small worms...only one type of worm, earthworm....

I: Well, we couldn't get involved with more than one type of worm. Why don't we just keep it to just one worm, the earthworm, for some simplicity here.

S: So, you are saying that the sense of smell and taste doesn't have anything to do with it. As you stated it....

I: No, no. We didn't come to that conclusion at all. If we took away the normal taste of the prey, then...possibly, eliminated a recognition factor here.

S: Then, to do that, I could take some, you know, something like a worm extract--smell and taste of a worm--and inject it into the small pieces of frogs and fish, you know, to try to comouflage their taste.

I: In other words, to make a fish taste like a worm.

S: Yeah. Like that. Some way fake the snake out to eat a worm.

I: All right. Such experiments have been done, and the way this has been done is to make extracts of various possible prey items--to make an extract of worms, crickets, frogs and fish and the like. And we actually use such things as Q-Tips--cotton swab on the end of a stick--and dip this into the various extracts and put these in front of the snake to see the reaction. Now, most times the snake is not trying to eat the cotton swab, but shows either interest by continued tongue flicking and tasting, or just trying it just once or twice and turning around and going away. And, if you did an experiment like this, you would find that the snakes were definitely interested in the worm extract and disinterested in the others. So, on the

basis of the observations of this experiments, what conclusions would draw? Now just on the basis of this experiment.

S: That a young snake did have a trait that he did like small worms--taste of worms.

I: All right. So, you have nicely now eliminated movement and size, shape, and color and come down to the conclusion that it is the taste of the prey that is attractive to the little snake. All right. Very good. Now, we need to back up here to the observation that here are these little snakes that crawl out of the egg and they come out and take a first look at the great wide world, and move off from the egg and find different kinds of things that are possible food items, and, yet, select only the earthworms to eat.

S: To do that I would....

I: Clever little snakes, aren't they?

S: To find out if it was the reason that he picked the worm--because he liked the smell of the worm...that would go into proving it...that it was what he acquired from his parents.

I: All right. This is an innate trait that is acquired from his parents. What kind of behavior do we call this?

S: First of all, the sense of smell....

I: We are thinking of behavior now of two different kinds.

S: What?

I: Well, you have the kind of behavior that is called instinctive and the kind you call learning.

S: Learned behavior couldn't be passed on then, could it? I mean, you know, just naturally. Then it would have to be instinctive, I guess.

It was passed on. And to prove this you would have to isolate the snake and instead of using that snake, use a snake--but don't, you know, have different generations of this snake--and, to take this yearning for swallowing worms, I think the snake would have to be--not the parents, but the kid--the second generation of snakes... would have to be in isolation and not have meat, you know, worms. He could have the fish, the frogs, the crickets--cut up--so they could eat them, but he wouldn't have worms. The second generation after him could be done the same way, you know....

I: But, he won't eat these things.

S: Not even if he was going to die?

I: That's right.

S: They don't eat them?

I: In many cases this is the situation--that a snake will eat only one kind of thing, and you could give it everything else under the sun to eat and they will starve to death instead of eating those. So, it is kind of hard to get another generation that way.

S: Yeah. If it is passed on...I think it would have to be in the genetics if it was passed on.

I: All right. I think you have just drawn a valid conclusion. Well, how can you demonstrate that this is not learned?

S: Well, the snake is still in its egg and you have to have two of them, I guess. And, have the diced up crickets and diced up fish and diced up worms, you know, as his first food. And, you know, have this over and over. And the first one he would go to would be the worm. If he went to that continually and along with this

other one--control group, I guess, to the worms continually, you know right away--then, I would say that it couldn't have been learned because he was just born. And then take away the worms and if he didn't eat the other stuff--the crickets and the fish--and that he is still eating the worms, then I think...then it couldn't have been learned, since he was first born. Or, take the mother snake away from him.

I: Well mother snakes just lay the eggs and then go on their way never even to see their own young. Or if they do, they wouldn't recognize them. There is no association--parental...no familial association here. So, you know he has never had an opportunity to learn.

S: Well, and isolate him away from any from other big snake and you would know it wasn't learned.

I: Well, I think that you have handled this accurately and, unless you have something else to add, I think you can terminate this discussion.

I: Now Tim, you just read the statement of the problem: the observation of the feeding habits of newly hatched snakes. This is a problem being posed to you; how would you go about investigating this situation in order to come up with some reasonable conclusions. Now, under normal circumstances, if you were a working scientist you would have access to a laboratory, libraries, and other kinds of resource materials. In this interview I am your resource material. In other words, what you would try to seek in a library you can ask me and I'll provide the information you would gain by going to the library, by going into the field, and by doing work in the laboratory. The thing for you to do is to design the investigation here. You can't just go to a library; you have to have a question in mind, right? You can pretend that I am a big book. When you go to the book you have to have a question in mind, and you're seeking an answer; so you can ask me these questions. So speak up and let's go.

S: First of all I'd pick up about...I'd get some snakes, about 50, and then I'd divide those up into groups, about 25 in each, the.... No, I think I better get a hundred snakes.

I: It's easier to figure percentages that way.

S: Yes.

I: All right, so you're going to have 100 snakes.

S: I'd divide the 100 snakes that are eating those worms and small frogs and first into two groups, 50 in each, then I'd feed half of each group the worms and then give them so much per day, and then in the other 25 of a group I'd give small fish and frogs; then in the other one, in each half group, in each group of 50, I'd give 25 snakes worms then in the other group of 50 I'd give frogs and fish.

I: Just on the basis of these field observations what can you say about the eating habits of these newly hatched snakes, of this particular kind of snake. Now I presume that when you said you were going to have 100, you were going to have 100 of this particular kind of snake.

S: Well, all these snakes were new, I don't know how long ago they were hatched, but say within a week. They liked worms better than frogs of fish.

I: So you have obtained 100 newly hatched snakes and divided them into two groups, one of which you are feeding only earthworms, and the other you are feeding frogs and fish into the cages that you have these snakes in. On the basis of the observation in the field, what would you expect from your experiment in the laboratory?

S: Well, from what they say, the snakes would eat the worms more.

I: Would you expect the snakes to eat the frogs or fish at all?

S: Yes, they would after a while; they'd get hungry.

I: You think they would.

S: Yes.

I: Well now suppose you've kept them in a cage now for a month, and not one of these small snakes has yet to eat a frog or fish.

S: Then they are going to die.

I: So they would be dying of starvation. Well, now why do you suppose they aren't eating the frog or the fish?

S: Well, they're alive. Well, maybe they don't have any way of killing them, or they're too small to kill them. Like they don't have any fangs like some snakes don't; like it's not a boa constrictor or something like that. It doesn't have any way of killing; the snake is too small for the animal.

I: What you're saying is that the size of the food item might have something to do with it.

S: A way of digesting it.

I: Or possibly just swallowing it.

S: Yes.

I: Are you familiar with garter snakes?

S: I've had a couple, yes.

I: Do you know how small a baby garter snake is, one recently born? Like maybe six inches. Now if you have a frog that is maybe three or four inches long, obviously the baby snake couldn't eat the frog. It might be the other way around really. We are faced here with a situation of the selectivity of the food, whether this is due to size or some other factor. Now can you suggest ways to attack this problem to determine what is the nature of this selection?

S: Get different kinds of snakes, like a snake that has fangs like a small boa constrictor. I don't know how many you'd get. Anyway you'd put them in a cage, then one week you'd give both so many... Say like ten snakes one kind like with fangs, the ten snakes that strangled food. Then feed them the same amount of crickets, frogs, or fish, and I'd see if it was size, if neither of them would eat the food until it became bigger. I think one of them would be able to.

I: Well, what pertinent questions can you think of, specific questions that might come to your mind. You could tap your available resources for here?

S: What kinds of snakes, I mean what ways of killing food is there for snakes? No, how do snakes kill their food?

I: All right now, let's briefly take care of that situation. Basically there are three ways: there are those that just grab their food in their mouths and swallow it, such as a garter snake does when eating an earthworm, insect or small frog; then there are those that grab their prey, wrap their body around it and constrict it, suffocating it such as done by rat snakes, boa constrictors and the like; and then there are the poisonous snakes that inject venom, such as copperhead and rattlesnake. They quickly bite, inject the venom and sit back and wait for the prey to die and then eat it. Now if we have a snake that is eating the earthworms, what type of feeding do you suppose that snake does?

S: Swallowing it.

I: Is it constricted or....

S: No, I say it just leaps on it.

I: All right Tim, go on.

S: You asked if a snake ate an earthworm, what way would he eat it - I mean kill it - and there are three ways like you said: swallowing, strangulation, and inject venom. I would think a snake that would eat an earthworm would just swallow it whole as most snakes are larger than worms.

I: All right, now you would think this. In a particular kind of snake like we're discussing here, how would you determine whether your ideas are correct?

S: Well, you'd have to find what kind of snake it is and if it starts out as a snake that large - I mean real small - then my ideas didn't work out.

I: Hou can you say you think that this snake will just grab the worms and swallow them; how can you determine this for sure?

S: Well, I'd say a snake, now I haven't seen very many baby snakes, but I'd say a snake would be larger than an earthworm, or about the same size, when it was born. Then I'd say that because a snake is larger than an earthworm, it would kind of hard to wrap around it, and then it would also be hard to inject the venom in something that small.

I: So you need to determine how the baby snake eats the earthworm. How are you going to determine this?

S: Well, you'd have to get certain...you'd have to get an example of the three ways of killing. You'd have to get a snake that shows

the three ways of killing the food.

I: Not one snake...

S: I mean three.

I: Well, we're only concerned right now with our one particular kind of snake.

S: Well, then you get that, then you'd see.... Well, you could just look it up. Well, perhaps you would go to your resource material and you don't find anything on how this particular kind of snake kills its prey. So then, what's your next step?

I: Well, you've been observing these snakes here.

S: Well, you'd get so many snakes, and then you'd have to bring them all up. I'd say you'd need not more than five in case some of them die. You'd just bring them up, just feed them live food and see how they kill the food.

I: All right, so you observe the nature of the method of feeding. We're getting a little bit off track. We have the situation of these young snakes, newly hatched snakes, that have been observed to feed only on earthworms, right? So do you conclude from this observation that these snakes feed only on earthworms, or is this just a chance observation, or perhaps they change their diet with age.

S: I'd say they change their diet with their age; they grow bigger; they need more food, so they go after larger prey.

I: Can you substantiate this, or is this just a wild idea that you have?

S: Well, when you are a kid, you can be fed once a day, and that's all

you need. Maybe not once a day, but you don't need that much food because you're not big. But as you get older you need more food. So just like a snake, as they grow larger, they need more food to live on so they'd have to find some way of killing their food; they'd be running around eating live earthworms.

I: So maybe they run around eating a lot of earthworms, or do they change and eat something bigger?

S: I'd say they change and eat something bigger.

I: How are you going to find out?

S: Well, I would say that earthworms are in the earth, and the snakes have their tunnels, I mean their caves, that they go into in the ground. The snakes are hidden all over, so then they'd have to go find where the snakes hide. It's kind of hard but I don't see that many snakes, unless you're doing some kind of digging. But, like the frogs, they're on the ground, and they can be in the water, or on the land and the snakes get them there. And the crickets are always on top of the land unless maybe they're hibernating and the fish, unless it's a water moccasin or something like that - some snake that can go into the water and get the fish.

I: Well, are you going to come to the conclusion that these things eat worms when they're little and something else when they're larger?

S: That's right; I'd say yes.

I: But so far as I know, the only observations you have are that on these field trips in this wildlife reservation you have observed baby snakes of this particular species eating only earthworms. Now based on these observations, do you think a conclusion that this snake eats only earthworms when he's young and something else when he's an adult is valid?

S: On what information we have here, my statement isn't valid. But just use common sense.

I: Sometimes common sense can lead you astray.

S: I mean just use plain logic.

I: Now the problem being put to you is: how we will solve this problem step by step. What's the information, the evidence, that you need, and from these bits of evidence, what valid conclusions can you draw?

S: I think we'd better find out what the problem is. I don't really understand that. From what I can tell, they've just given you information but....

I: Well, what questions come to your mind here? Say you're out walking around and you notice these little baby snakes. You actually find some eggs hatching, and these little snakes come out of the egg and start crawling around. The first thing you know, here comes an earthworm by and wham! one of them grabs an earthworm. Here you see another one coming out, and here's a cricket hop by. He pays no attention to the cricket; he goes on till he sees an earthworm and grabs it.

S: Well, the earthworm is slower, and then, the snake can't catch

a cricket or the frog; all those are too fast.

I: Now, this is a valid observation, a point to make, I believe. Obviously a cricket is much more agile than an earthworm, and the frog is, too. But now you conclude... Well gee, these poor little baby snakes can't catch crickets or frogs; they hop away too fast... But suppose you take some of these little snakes home and you start to wonder if they would eat frogs or crickets or whether they'll just eat earthworms. Can you devise any kind of experiment to test the hypothesis that these snakes will eat only earthworms?

S: Well, you could. You don't need one group for this...ten or so. Have them by themselves, maybe even less than ten; then you'd give them earthworms at first. Then they'd, from what they're saying here, they'd eat the earthworms. Then at the next feeding you'd give them the meat of a frog, or fish, or crickets, and try and make it not the same size of a worm but around the same size. If they don't eat...I mean just keep on going. Maybe it takes awhile that they...well, the first young, they don't eat the food, I mean the frogs or anything, but as they get older they do. You just keep that experiment up for I'd say a month - no more than a month.

I: All right, you are sitting here right now. You don't know what your results from this experiment would be, but let me draw from my experience and say in selecting a certain kind of snake, no matter what you did to crickets or fish or frogs, cutting up pieces of meat and so on, you would not be able to get these snakes to

eat anything but earthworms. Now, does this provide you with any further problems for investigation? All attempts to feed them anything else have failed; you can't get them to eat anything but an earthworm.

S: Well, after a month and they still won't eat anything but worms, you'd feed them earthworms and frog meat, or a combination of frog meat and crickets and fish. Then you just go back and forth; you go worms, and combination of all the food, and then worms... back and forth. Then if they wouldn't eat that; crickets, frogs or fish, I would say about the end of the month that the snakes ate... they just ate worms; they didn't want the frogs or fish.

I: These little snakes observed these worms just as they came out of the egg, and the first thing they did was turn around and grab a worm and start eating. Now does this observation give you any hint as to what the controlling mechanism might be?

S: Well, they might be hatched inside the ground, and I don't know....

I: Well, let me ask you this. What was your first thing that you ever ate?

S: When I was born?

I: Yes.

S: I guess it would be milk.

I: This seems to be a natural thing with human babies and other kinds of mammals. When they are born they have the sucking action

already. Maybe you still drink milk, but obviously your diet has changed considerably over the years. Did anyone have to teach you to drink milk?

S: Well, no. I guess you could say that snakes - they just have a natural thing for worms.

I: All right, that this is something instinctive in the snake to eat worms....

S: But as they grow up they need more food. I still drink milk but I also eat a lot of other stuff too.

I: Right now you put your finger on a point that I think is worth pursuing - that the young snake, perhaps you say is instinctive, for the young snake to eat earthworms. How could you test this hypothesis?

S: Well, like get some newly hatched snakes and some snakes that have been born for about, say, two or three weeks. Then you just feed them; I mean you put earthworms in there, and then you'd let that work out for about a week. You know, keep on feeding them that, and if the snakes, if both snakes eat it...no....You would feed earthworms to the young ones. See you'd need some young snakes that had just been born, and you'd just feed them earthworms. Then in the next group of snakes that are about three weeks old or so, you'd feed them earthworms and then frogs and fish and crickets, but they wouldn't be all on...you'd feed them worms, and then at the next feeding you'd feed them frogs or crickets.

I: All right. Now how is it in both of these groups of snakes that the only thing any of them took were earthworms?

S: Then you'd conclude that they always ate earthworms, that was their natural instinct.

I: All right, is this really instinctive? What is it about an earthworm that makes a snake....

S: Well, it's slower....

I: All right, but a piece of frog muscle is even slower - frog meat?

S: Well, I'm talking about a frog muscle, slower did you say?

I: Well, just a dead piece of frog laying there that you were talking about earlier.

S: Well, I'm talking about all this is live, but when they're all alive... I think that when snakes are just first born they would rather have, they would have to take worms because they're slower, but as they got on the older...they are faster and they have better ways of killing their food.

I: What about slugs or things like this. There are some very, very slow-moving insects.

S: Well, if they....Well, what I know from my experience at home, finding slugs, they're kind of hard to kill unless they're....I don't think a snake could kill it, a newly-born one. Cause, like the only way of killing it is putting some salt on it or something; I think that's it.

I: All right, let's look at one aspect of the problem here in a little more detail. So far in your observations your snakes eat only

earthworms, and the fact that recently hatched snakes feed exclusively on earthworms and the little snake he...the feeling he has when he comes out the egg and faces the great wide world is to go off and eat an earthworm. Have you thought as to how that little snake knows that an earthworm...and you're saying that this is something built into the snake, that it is instinctive for him to eat earthworms. It has never seen one before.

S: Well, we never knew how milk tasted before we were born, but like you say, we came up with a sucking action. So then it would be natural. Now how they know where it is....

I: Well, do you suppose that you could experiment with babies and have bottles, baby bottles with different kinds of fluids in it?

S: Well, I don't think they'd know just by looking at it, but I don't really know that they'd really rather have milk or water or coke or anything; but I assume that if you gave a baby a bottle he would start sucking on it. But like if you gave him water, I guess he'd drink that, but he wouldn't drink that for long; he'd still be hungry.

I: Well, suppose you gave Coca-Cola.

S: Well, I don't think he would really like that cause it has no food content because that's all the food the baby gets.

I: Well now in a case where little snakes...I think we're on the same line now that you just were. Do you suppose that you could devise some kind of experiment to test whether with this snake it was the movement of the earthworm, the size of the earthworm, the sight

of the earthworm, the tasteor smell of the earthworm that attracted the baby snake because of his instincts?

S: Well, you take some worms, then some frogs, but all of this would be cut up, so I don't know if the crickets.... You could make it look like earthworms, but all of it that would look like it, and all of it would be dead. Then you'd have a baby snake, and I don't know...I'd have to do the experiment to see, just like you'd have to the experiment with the baby to see if it likes Coca Cola better than milk. But then it's probably simple; I don't think it would know just by the sight of it, or I don't know about the smell; I think it would just be by the taste of it just like some animals are born enemies of others.

I: Okay, so you're going on to the taste aspect of it now. Here perhaps I should introduce a bit of evidence that I would have hoped you would have sought out in your library resource. Snakes actually do have very sensitive taste, or sometimes you could even call it smell because sometimes they can pick up the chemical sensation from the air by flipping the tongue, and the tongue has gone back into the mouth and pushed up into a little cavity in the roof of the mouth where there is a very specialized gland called Jacobson's gland. This sends a message to the brain of what type of thing the snake's tongue has come in contact with. So the snake has his tongue out here all the time; he is actually tasting or smelling the air or whatever thing he has put his tongue up against. It has been shown here in one particular publication on this subject...a man

tested the chemical preferences in new born snakes of three different kinds of water snakes. What he did was use extracts of the prey, water extracts, all it was was a cotton wad, and this one tasted like crayfish, this one tasted like frog, and the next one tasted... just like when your mother used vanilla extract in her cooking. Well, this had frog extract and crayfish extract and so on. You can see here from the draft of the different percentages of individuals that one species was mostly interested in crayfish; another, if you look down here, was mostly interested in frogs. So on the basis of this information, you can see here that snakes can and do distinguish prey items on the basis of taste or smell. In the next two minutes here do you think that you could draw some conclusions?

S: Well, that different kinds of snakes prefer certain kinds of meat or animals. You said you have three kinds of snakes; that one one of them liked crayfish, and the other one liked frogs. I forget what the third group....

I: Let me point out again that these tests were made on newly born snakes that had never fed; they were born in captivity and had never seen any kind of food item. They'd never been subjected to food except these cotton swabs that were dipped in different kinds of extract.

S: Well, when a kid is born he doesn't know where he is; he is about the same example really.

I: All right. So now you have observed that these particular little snakes feed only on earthworms, and they do this immediately upon hatching. You have found that snakes are chemically selective in their food items. So what conclusions can you draw now as to the feeding habits of recently hatched snakes?

S: Well that they prefer a certain kind of food to another, I guess you'd say.

I: Well, what kind of a preference is this; is this a learned preference or is it an instinctive preference?

S: I'd say it was instinctive preference, but if a snake didn't have any of that feeling, I think it would learn to want something else just like the survival of the fish, I mean adapting to their environment.

I: That's just about all you can conclude from this? This terminates the interview with Tim Dolan.

I: You've read the statement of the problem and are now ready to delve into presenting the ideas you have. Ask any specific questions you wish so that you can formulate some further ideas, and hopefully, come to some valid conclusions.

S: First, why did the young snakes...they took the worms, but how come they didn't eat the crickets, small frogs and fish?

I: Well, first, this is the question we are asking you.

S: First off, I'm kind of confused. What was the point of the fifteen field trips?

I: It could have been 15. It could have been twenty. It was just a period of a number of field trips

S: Young snakes, can they not eat these cricket? I mean, is it against their digestive system?

I: Well, it might be, but let's assume this information is unavailable.

S: Do you want me to, like form a hypothesis or something on an experiment on how I would go about finding out why?

I: Yes, this is the purpose. Let's assume you're the individual who had made these fifteen field trips. And you observed these baby snakes of this particular kind, and they all seem to eat--earthworms and nothing else. That's the only thing you've observed, I mean. So what questions pop into your mind on the basis of these observations? and then what? How would you go about answering these questions, and what information do you need to answer these questions?

S: Like those first two questions--why they wouldn't eat it means that it's against their digestive systems. I suppose maybe you could take so many snakes and put them in one place. And let five in one

place and five in another, and feed one five with the earthworms and the oth five with the crickets and small frogs, and see what happens with th

I: All rig let's assume you do this. You collected baby snakes just as they ame out of their shells, and you put them in two different containers. And to one group you fed earthworms and one group you fed frogs and crickets. Now since I'm acting as your resource material on a laboratory experiment, let's assume that the ones you fed earthworms ate the worms, and those you fed crickets and frogs did not eat the crickets and frogs.

S: Well, that kind of takes you back to the beginning and start over. You might separate them again and say feed...no that probably wouldn't result in much. You could take some baby snakes and feed them earthworms and the crickets and small frogs. Then you could take full grown snakes and feed them the same things and see what the results would be.

I: All right, let me ask you a question or two in here. Would you expect the adult snakes to eat the same things as the recently hatched ones? The same kinds of foods?

S: Well, they probably eat earthworms too, but they might be able to also devour the crickets and small frogs. It might be that baby snakes are too small to eat the frogs and fish and crickets.

I: You're saying that there might be a size factor involved here. All right, this is an idea worthwhile to pursue. Well, you say that it might be size factor involved, so how can you test that size really is related here? Obviously a six-inch baby snake is not going to eat

a four-inch frog, but the size and shape of the prey has something to do with the selectivity.

S: Well, you could, like, take the small ones and feed them the crickets, and the large ones and feed them. And say the experiment resulted in the large ones eating crickets and the small ones didn't. It would be mostly size. It says a certain species of snakes. It might be that this species doesn't eat the cricket or the frogs. I don't know.

I: Now let's look at this from another way. Suppose you observe two different kinds of recently-hatched snakes, one kind fed on earthworms and another kind fed on young frogs.

S: Then you could maybe take the ones that fed on the earthworms and feed them earthworms and the frogs, and the ones that fed on the frogs...feed them the frogs and then some earthworms and see what the result would be if they....Well, that doesn't sound too good.

I: What result would you expect on this?

S: See that's what I mean. The ones that ate earthworms would not even look at the frogs, and the ones that ate frogs wouldn't look at the earthworms.

I: All right, so now you've established that they can have food preferences of different kinds in different species of snakes. Right?

S: Yes.

I: In other words all baby snakes of all different kinds of species do not necessarily eat earthworms?

S: Right.

I: Well, where can we go from here?

S: Well, find the ones that...separate them, I suppose, in categories of what they eat. Like some will eat earthworms and others won't. Some might eat the frogs. Then some might eat both. I'm really kind of stumped here. I mean I'm not getting the point of what I'm supposed to do. Do you want...?No I think I know what you want now.

I: Well, you've made these observations. Several questions can be asked, which you already started. You've brought in the point very nicely that size might have something to do with it. That obviously a baby snake can't eat very big items of prey. You wouldn't expect him to go after large frogs or fish or something like this because he just can't eat them. Now, what other attack can you take on this? Remember now, these little snakes are coming out of the egg. They've never seen anything to eat. They've never seen anything before. And the first thing they start to eat...or the only thing they eat are earthworms. Now does this observation itself raise any kind of questions in your mind?

S: Well, the point that they haven't seen anything to eat before....The earthworms might be the ones that would attract them the most. The crickets and frogs wouldn't appeal to them.

I: Well, what do you mean by attract and not appeal?

S: The snakes would be interested--more interested in eating the...they might somehow favor the earthworms to the crickets and frogs and small fish.

I: All right so you're saying there is something about an earthworm that is more appealing to the snake than a frog or a cricket. How could you test this?

S: You could, like I said earlier, separate them and feed some the crickets

and frogs and earthworms. And if they just ate the earthworms, they would prefer the earthworms and not the small frogs and crickets.

I: So you again return with the same observations that you've already made. You have no new observation here. Do you suppose there might be something special about an earthworm that is attractive to the snake?

S: There must be.

I: Well how could you determine if there is, or what it is about the earthworm....

S: First you could determine that they were more interested in the earthworms because they preferred them over the crickets, small fish and snakes. And then you might, if it is possible, give them different types of worms or similiarities with certain characteristics, and the one they eat... you take the characteristic of that particular, say, worm or something. You'd have an idea of what they were interested in.

I: I think perhaps you might need to go to your resources a little bit more now. Learn something about snakes and their feeding....anymore questions come to your mind on that subject that you feel you need some information?

S: What snakes eat. Well, the different kinds of species, which ones prefer earthworms and which ones prefer other kinds of food. If they are insects or little larger animals.

I: Well I can tell you that some kinds of recently hatched or recently born snakes feed primarily--almost exclusively--on earthworms. There are other kinds of snakes--baby snakes--that feed on frogs, insects, or what have you. So not all baby snakes feed on earthworms, but there are some that do. There are also some snakes that feed almost exclusively on earthworms throughout their lives.

S: Well, then this particular species feed only on earthworms. You could come to the conclusion that this certain species of snakes prefer only worms, or similarities to the worm.

I: Well, how could you determine this? I mean you can observe that they do eat earthworms and, in quotations marks, they definitely prefer earthworms. If you give them a choice they always take the earthworms.

S: All right. Well, then you could take two species of snakes, and one species you'd feed...the species that didn't prefer....Wait a minute. First you take the species that prefers the earthworms, and you feed them earthworms first. And then they would eat them all, and then you give these same snakes a different type of food, say, crickets and frogs. And if they didn't eat them then you would come to the conclusion that earthworms were their main source of food.

I: All right. I think that's a reasonable conclusion, but there was one aspect of this you haven't really touched on yet, which is on of the most interesting aspects. You will note here in your statement that recently hatched snakes, in other words, do feed only on earthworms.

S: Well, you take the recently hatched ones and they prefer earthworms. And then maybe take the ones that aren't newly born and feed them the same thing. And if they eat the earthworms, then feed them something else. And if they ate, like, crickets or frogs, it also means that newly born snakes of this particular species can only, say, digest or only...the only thing that really attracts them, would be the earthworms.

I: Now we're getting this off on something else here that is interesting. You say attract the earthworms. All right do you suppose there's something about an earthworm that is appealing to the snake? The snake is interested only in your earthworm and not a cricket or a frog or a fish?

S: Well it may be the baby snakes are only interested in the earthworms, and as they grow....

I: Well I was referring here just to the baby snakes. Well, I think now in

this point again, Steve, you need to utilize your resource materials for more information. That could help you along here. So what questions come up to your mind so far as the actual feeding coming? Do you know snakes can see? Can they smell? Can they taste?

S: Well, you'd have to find that out by reference. They might sense.

I: Maybe it's time for you to start asking some questions is what I'm trying to get at here.

S: Well, then you'd have to know what attracts them to earthworms. Is it like sight, taste, smell, sensing any type of sounds? Do snakes of these certain species of snakes, as they grow larger do they still only prefer earthworms, or do they also besides eating earthworms go on eating crickets, small frogs and small fish?

I: Well are you asking me these questions for getting information?

S: Well these are questions that I would ask myself.

I: All right. Let's just start with this last question you just asked about--if there is a change in diet with age, increase in size. Now in many snakes there is a change. For example, the local snakes here--copperheads--start feeding primarily on insects and little frogs and baby snakes, and as it matures and grows larger, the diet changes, to when it's an adult its feeding primarily on mice. Well obviously, a baby cooperhead isn't going to feed primarily on mice because it couldn't eat them. Many kinds of snakes do change their diet noticeably with growth because either their mechanism of feeding makes it extremely difficult to eat small prey items when they are large snakes....

S: Yes they might need...earthworms and crickets wouldn't satisfy their need for food.

I: That's only one of the correct....The other thing is about their ability to....What if the earthworm attracted the snake? Well, snakes are able

to see. They don't have the best sight in the world, but they're quick to notice movements. In other words, a snake can be crawling through the grass and a frog is sitting there. The snake might crawl right past that frog and never notice it, as long as the frog didn't move, because if the frog moves the snake would probably immediately take notice of it. Also we must regard, as you've mentioned, snakes' taste. And let's visualize the term taste, in quotation marks if you will. You know you've seen snakes flipping their tongues out. Now this is a sense of taste or smell. So, drawing this tongue, which is not actually stickey, but is moist back in the mouth, and putting the tips of the forked tongue into a specialized gland in the roof of the mouth called Jacobson's organ, it can derive chemical sensations the way you do from smelling. I mean you get a different sensation from different kinds of smells. The chemistry lab here in school smells like one thing, and an apple pie and others at home smell different. And you have different psychological and physiological reactions to these different things. Taste the same way. So a snake does have these abilities much in the same way you do with the sense of taste and smell. Bearing this kind of information, you are now faced again with the situation that these little snakes feed only on earthworms, and wonder why do they feed only on earthworms?

S: Well, like you said, where they notice movement. They don't have very good eyesight. A small earthworm would probably tend to move quite a bit, therefore the snake would be attracted to it. And then possibly these crickets and small frogs and fish might....Fish. Would they be dead fish?

I: It could be live fish or dead.

Well, the fish would probably move too, but if they were dead then they wouldn't move at all. And the crickets and the frog wouldn't necessarily

be moving continuously. And the earthworm moves a lot without too much stop. So therefore, the snake would be more attracted to him because of this movement, and he wouldn't be attracted to the crickets and the frogs and fish a lot because they weren't moving about continuously.

I: All right now, you say movement may have a significant....

S: Yes, that it might attract them.

I: How could you test the movement as important. How can you devise an experiment where you eliminate the fact of movement, or eliminate all other factors except movement.

S: Well, you take a certain amount of snakes, place some with food....well, with worms and anything that has a lot of continuous movement, and if the snakes were attracted to this and they ate this food, you'd be reasonably sure they were attracted to movement. Then you could take these same snakes, put them with something that doesn't move a lot....like frogs aren't continuously moving or crickets, and if they didn't really pay a lot of attention to them, you could be reasonably sure that it was the movement that attracted them.

I: Maybe it's the shape or the color.

S: Well there we'd have to really come in with eyesight though...wouldn't it... because color....

I: But see you haven't eliminated this possibility. In other words, you've got worms crawling around. You say the snakes eat the worms because they move. Will the snakes eat the worms if they don't move?

S: All right, if they should have a certain color, then they would. You could put the snakes in with the worms. Say some of them didn't move a lot and they were....

I: Now how can you make sure the worms don't move?

S: Well, let's say that they ate worms of say, a very like color and... No, let's say they ate all--say maybe a variety of color. And these worms all moved, and you could say it was movement. But if they were...say there was a variety of color. The majority of earthworm that the snakes ate were a lighter color. Then you might say that a lighter color attracts them more.

I: All right, let's get back to this movement. How can you test whether movement is important if this snake's eating earthworms? You stated earlier that you thought this slow and continuous movement of the earthworm might attract the snake. Well, how can you test whether this is a valid assumption or not?

S: Well, you might be able to take a certain kind of worm or something that is, say, continually moving or something, or isn't real, doesn't linger a lot, moving very--I should say--quickly but continuously, and the snakes eat these worms. And then you put the snakes with worms. I'm not sure if this is logical, but if you could take some worms that were not really a type or similarity to a worm, or a worm that doesn't move a lot, say for instance, a slug or something like that....

I; See, now you're introducing an entirely different kind of food element. Why don't you just kill the worms? I mean a moving worm versus a non-moving worm. And a sure way of having a non-moving worm is having a dead worm usually.

S: All right. Well you could cover two points if they ate the worms that were dead. We'd know that movement didn't have a lot to do with it, but color might have something to do with it. The color of the dead worms.

I: The only thing you've done is eliminated the fact of movement here. The factor that they eat dead worms as readily as live moving worms... well the movement of the live worms is not the thing that attracts the

snake to the worm.

S: But if they don't eat the dead worm, then you'll know movement is the attracting force.

I: All right, just to simplify things, let's assume they do eat the dead worms. All right, if they ate both the dead and live worms, that would eliminate movement, and you might ask the question, "Is color a factor in why the snakes ate certain types of earthworm?"

I: All right, you've eliminated the problem of movement. Now can you think of a way to eliminate color?

S: Well, you take earthworms of a variety of colors...say, three varieties of colors.

I: Do earthworms come in different colors?

S: I don't know. Well, there would probably be a light and dark color.... Well, say, take worms of a lighter color and the snakes ate them, and then you take maybe a darker color earthworm and the snakes didn't eat them. Color would be a factor. The light color...Well, so if they ate the darker instead of the lighter, then you know they prefer the lighter. If they ate both of them you would know color isn't a very big factor.

I: Well, let's assume they ate both of them. In fact, let's assume they ate every kind of earthworm no matter what you do to the earthworm. I mean you've developed logically now a couple of ways of eliminating different factors here. You showed how to eliminate the color factor and the movement factor, and you could keep going and eliminate one factor after another so it comes down to the pure simple fact that these snakes like earthworms. Now why did they eat earthworms? I mean, why would this poor little snake...struggles out of his leathery shell, pokes his head out in the great wide world for the first time, seeks his first meal that's an earthworm. And each member of this clutch of 20 or 38, how many

it is, does the same thing.

S: And they don't eat the other crickets and small frogs. Well it possibly might be a form of taste that appeals to them. Let's see...

I: See, these baby snakes have made no effort to observe, to even attempt to eat anything else. So you're here talking about food preferences as though based on some kind of experience. You know they like the taste of an earthworm better than they like the taste of a cricket. But they've never tasted an earthworm or a cricket. Now the important thing to keep in mind here, Steve, is the fact these little snakes are doing this. These observations are made of little snakes in the first few minutes of their life.

S: When you mentioned that copperheads ate other baby snakes, it might be that since the worm is like a snake in the same structure form, these snakes might be more attracted to some....

I: Why are they attracted here? This is what we need to get off into. I mean, it is obvious that they are attracted, and it's obvious they do this immediately upon birth or hatching. So what does this infer to you?

S: Well, that they just prefer earthworms.

I: How is it that they prefer earthworms?

S: Well, it says in the thing they prefer them because they don't eat the other animals. Because they don't eat the other animals that are around, or insects that are around.

I: Now you do a little bit of circular reasoning here. Well tell me, what was the first meal you ever ate in your life?

S: Milk, possibly.

I: That's a pretty good guess although you can't remember, but why did you eat milk? Or drink milk as the case may be.

S: Wouldn't it be related to the snakes who prefer the earthworms because their like of their own type or structure.

I: Did you drink, as a baby, take milk out of a bottle because....That one kind of backfired didn't it. Human babies. Immediately upon birth they are equiped to, and actually do suck on milk. What happens if you have a new born baby a hot dog to eat?

S: He couldn't digest it; he couldn't eat it.

I: He couldn't eat it. All right. This is rather obvious. This is like giving a baby snake a four inch frog to eat. He can't. By the time he grows up, this snake three feet long might eat that. It's like a kid By the time he grows up to be six years old, he'll be plenty happy to eat a hot dog. Now let me ask you this. Suppose you're babysitting some evening and it's time to feed the kid. You stumble into the refrigerator and pull the bottle out and heat it up, and what you accidentally did was to fill the baby bottle with Coca Cola instead of milk. Well?

S: Well the kid wouldn't eat it or drink it. Wouldn't be able to. It would be the nature let's say. Well....

I: Well do you suppose you'd get an immediate reaction after the first suck that there is something wrong here.

S: Yes.

I: But milk, this is all right. There is obviously an ability to tell the difference. Where does this ability come from?

S: Nature.

I: You're saying that the kid is born with it?

S: He must be because if he....

I: All right. Now we're getting off in another interesting line here, and we've only got a few minutes. Okay. This is what we call instinctive.

S: Wouldn't it be instinctive for snakes of this certain species if they all ate these earthworms...like the new born baby preferring the milk. Like it would be natural for them first to devour these earthworms.

I: All right, you're coming out with the idea now that the behavior of this newly hatched snake is to eat on earthworms and nothing else.

S: Well, that would be the first thing they feed on.

I: This is an extremely good point, but again this is a hypothesis. You have to test it. Can you think of any ways you can test this to obtain your hypothesis, your conclusion?

S: Well, let's see, feed these snakes the earthworms when they are.... also feed them, say, some other type of food--animal insect. Then they prefer...say they eat the earthworms. Maybe feed the same species of snakes, only older ones, and if they ate that...No that really is getting off the.....Well, if you're going....Well first you'd have to feed them earthworms, and if they ate the earthworms you'd know they were attracted to them. Then you'd try to feed them some other insect like crickets, or, small frogs or something, and if they didn't eat those you'd know they were...it was more natural for them to eat the worms.

I: All right, but how could you demonstrate that this feeding preference is something that is instinctive and not learned?

S: Well, as soon as they are hatched they go out and eat the earthworm. They wouldn't have time to...say, like a bird is fed by the mother the worms. The snake just goes right out and eats the worms without any help. You'd know that it was natural for them to go and eat the worms.

I: All right. So now Steve, what conclusions do you draw from these observations on information you gained from your "resource material" here this morning.

S: Well, that it is natural for young snakes to eat earthworms. It is instinctive for them to do that, and that as they are newly hatched they really don't prefer anything else. They don't eat the cricket or the frog or any small insect.

I: That should just about wrap it up.

I: This is an interview on the problem of preferential feeding of newly-hatched snakes. Go ahead.

S: Well, I think the first thing I'd do would be to go out to the field and observe how they're ... you know, where there will be snakes... to see if they took in the crickets or not... if they would be any different, you know.

I: All right. You are asking me if adults have different feeding habits than the juveniles?

S: Umm-hmm.

I: This depends. Some snakes do have essentially the same feeding habits throughout life. Others change markedly, with juveniles eating one kind of food and the adults eating something entirely different. Usually a larger item of food. Larger kind of prey.

S: Well, then, maybe these baby snakes saw that their.... Well, adults weren't taking any crickets and frogs, so they just didn't think that was what they were supposed to eat. You know, taking after their parents. Could that be?

I: Are you saying here they learn from their parents?

S: Umm-hmm. Taking, you know, like...Well when I was a child, when I saw what my mother would eat, I would kind of have a tendency to do the same.

I: So. Imitation behavior. All right. Now you are suggesting, are you then, that this is the way the little snakes will imitate their parents? All right. Now can you design some kind of an experiment to prove or disprove this hypothesis?

S: Well, putting...go out into the field and collect crickets and small

frogs and small fish, and put them in like in one pile. And then taking larger things or just different kinds of food, and let these, you know, small snakes--baby snakes or whatever you want to call them--go out and see which ones they would pick up. Or, you could have, like the parents of these snakes. You know, let out first and have the other ones watch what the parents went to--the larger or different kind of food. And if the baby snakes go to the larger or different kind of food, maybe that would prove what they are imitating.

I: All right. Well, let us assume in this case that the adult snakes ate frogs and the baby snakes ate earthworms. You had a nice big cage and you put four or five adult snakes and a dozen baby snakes in the same cage, and you put lots of frogs and lots of earthworms in the cage. And observed that the adult snakes ate frogs and the baby snakes ate the worms. Now this is a possible result in this experiment that you have just set up. Can you conclude anything from it?

S: Well, that baby snakes don't always imitate the elder one.

I: I think here you need some more information, and that is that snakes that lay eggs...the mating may take place in May, and the male goes that way and the female goes that way and they never see one another again. And the female lays the eggs in June here under this log or something, and she goes on her way. In August, the eggs hatch, and mamma might be a half-mile away, or some small boy may have picked her up and she is now confined in a cage somewhere, or she has gotten run over on the highway or something in the meantime. In other words, the baby snakes never would see their own mother in nature;

it would be purely accidental and there would be no recognition whatsoever either way as far as individuals are concerned. The baby snakes would not... I mean, if they would see this other adult snake of their own kind that is all it is--an adult snake of their own kind. There is no familial recognition.

S: Well, there is one time of the year, you know, when there are more worms around than frogs and crickets and things. There are more out running around.

I: In other words, you are thinking now of the availability of food.

S: Umm-hmm.

I: Yes, this does vary different times of the year. And obviously we know that earthworms must be fairly abundant at the time these little snakes are hatching because that is what they are eating. But we also know from our observations that crickets and frogs and other things are available too.

S: Hmmm.... Maybe these snakes didn't...Well, while they're, you know, going around and doing a movement, you know people watching the snakes, could it be possible that they didn't see these--the crickets, frogs, you know? You know playing a game with the environment, or just selection now... they just didn't see these crickets.

I: Well, yes, this is possible. In other words, you are saying that the little snakes are eating what they are able to see.

S: Umm-hmm.

I: All right. Now, again you have a hypothesis here. They are feeding on what they can see. Can you set up an experiment to test this hypothesis?

S: Well, they could be in an area and, you know, just set out different

kinds of food that they might eat, and you know, kind of conceal them. Or you might put a green frog with a clump of leaves that kind of blends in or something and see if the snake could pick the frog, or one that is not so concealing like a, you know, brown worm on light sand or something.

I: All right. Let us see. You have set up this experiment with frogs in a cage: green frogs in a green cage, green frogs in a red cage, black crickets in a black cage, black crickets in a white cage, brown earthworms in a brown cage and brown earthworms in a white cage. What we would have here in each case would be where the prey is concealed as far as color, and a case in which it is obvious. And, as the result of this experiment, the snakes did not eat any frogs, or any crickets, or in any combinations of cages. They only ate earthworms in both brown cages and white cages. This would be the result of that experiment of things.

S: Now, in this problem did they try at all...taste or anything? I mean like, say that they tested one of these things and then they learned....

I: What was your observation here? The little snakes, immediately upon coming from the eggs, fed on earthworms but nothing else. Now, you have just...you were talking about the snakes tasting different things and not liking them, so to speak. Here you need some additional information.

S: I think I would go to the library...about snakes. Would it have anything in there about what they like, you know, to eat? Or what could be harmful?

I: You already know that these snakes like earthworms.

S: Umm-hmm. But, I mean, would it say anything about frogs and ...

I: Well, if you looked up food habits in different kinds of snakes you would find that there are some kinds of snakes that eat almost exclusively frogs; and other kinds of snakes eat almost exclusively crickets. Some, you know, eat only earthworms. Some that eat all three.

S: Maybe this was the kind that only ate earthworms. If they had a picture in like...went to a World Book or something, and they had a picture on this, and I observed the same snakes that, you know, I saw out in the field and they are just alike or the same characteristics, well then I would assume that they were the same kind of snakes and eat only earthworms.

I: All right. So you identify your snake as a species that feeds almost exclusively or exclusively on earthworms. Every time that anyone has looked in their stomachs and made observations of them it has always been earthworms.

S: I'm kind of confused now.

I: Well, you say you are going to look up and see about their food habits, and everything you could find on this particular kind of snake says they eat earthworms. There is no mention of their ever eating anything else. That would simplify things. We will know that the dumb snake only eats earthworms. Well, now here you have a little snake that comes out of the egg. He finally struggles out of this very leathery shell, pokes its head out, and takes its first look at the world, crawls out of the egg, crawls over here, finds an earthworm, and eats it.

S: Could it be some kind of instinct? Or, would it be just imitating? But it hasn't seen its parents.

I: Now this is the first earthworm he has ever seen. And it is a very good chance he has never seen another snake. He may have been the first one of the clutch that hatched and crawled two feet away, and here was an earthworm and he ate it. Now you say this may be instinct. All right. This is a very good idea. But can you set up a hypothesis now? And design some experiments to prove or disprove this?

S: I think... well, I think I would first test, you know, before I really set up any kind of a thing. Ah... observing just different... well, if you came to hatch some snake eggs and put them out in the field or whatever and see, you know, if they ... if it would go right out and eat the earthworms. Ah....

I: Well, this is the observation that is reported here.

S: I was thinking now that this is by instinct that they eat the earthworms. Are you saying that?

I: I am not saying anything.

S: Oh.

I: I have the information here in the book.

S: Well. Okay.

I: Now, you may assume this if you want to.

S: From all my observations, I assume that it is by instinct they went out and just ate the earthworms.

I: All right. Now can you tell me your assumption... into a valid conclusion?

S: That they are. That it is just by instinct.

I: Okay. This now in a state of being a theory.

S: Oh.

I: You have some observations. They are unexplainable by any other means to you than that this is instinctive or innate behavior. How can you prove this? And, what is it about an earthworm? You say the little snake goes out and instinctively eats an earthworm. Well, how does he even know that it is an earthworm? What is it about an earthworm that makes him eat it?

S: Could the snake... he hasn't seen any other snakes? I mean, you know....

I: He's fresh out into the world.

S: The earthworm just looks good. Well, if he goes out and is looking for something to eat....Well, just like a duck. When he gets into the water he just naturally knows how to swim. That's instinct. He just goes out and eats it.

I: Well, I think you are on to a very valid point here. But how are you going to prove this? Assumptions are a dime-a-dozen.

S: I've got to prove that it was instinct?

I: Well, if this is your theory, you very nicely could.

S: I don't know.

I: Can you set up some experiments on how to demonstrate that it has to be instinct, and what is the behavior response pattern of this garter snake, or whatever kind of snake this is, to an earthworm when it first encountered it?

S: Just watch, like I said, just watch other snakes hatching. See if they all do the same.

I: All right. Let's say they all do the same.

S: Well, I'd think it was by instinct.

I: All right. Let's complicate the situation. What is it about an earthworm that causes the little baby snakes to instinctively eat this?

I: How does the baby snake recognize an earthworm? In other words, you say that it is instinct...something that is imprinted in the little snake's brain that, as it comes crawling out of that egg and thinks, "Boy oh boy, it is a big wide world and here I am and here are the earthworms--just what I was supposed to eat." He has never seen an earthworm. Yet the first earthworm he comes across he eats.

S: Maybe the little snake thinks that...well, you know, he is long and has no legs or anything, just like a snake.

I: So you would say there is the association between similarity of body shaping of the snake and the type of thing he eats.

S: Yeah.

I: All right. This is a valid line of thought, possibly, on little snakes to eat earthworms. What about these snakes that eat frogs? Or crickets?

S: I don't know. Well, if they are hungry, I guess they will eat anything.

I: All right. Can you set up another experiment to test this?

S: Well, we can start with a snake over here along this path or something, or maybe have it boxed well so that he has to go a certain path and then, you know, along the way give it kinds of food like worms, then frog, and see what he would go to to eat.

I: Well, let's set something up that will be a little more controlled. Suppose you have a hundred snake eggs and they all hatched, so you got a hundred baby snakes all just fresh out of the egg. They have never eaten anything yet; and you put these in different cages. Now could you set up an experiment on this? Where you've got ten cages and ten baby snakes in each one? And, you want to study food products. What would you do?

S: Well, say, if they were just anything...in one cage have one type of food and in another cage have, you know, in this cage you have frogs and in this cage you have earthworms and in this cage, you know, you have something else, and maybe in the next cage have a variety or something.

I: All right.

S: And see if all these snakes were the same kind, and then if they ate just earthworms I would assume that that kind of snake, you know, this snake with the earthworms ate the earthworms, and all the other snakes would not eat their food. Then, I would assume that this snake would just eat earthworms.

I: All right. I think you could set up this experiment and you would have your different cages with different kinds of food items singled out--frogs in one, crickets in another, earthworms in another--earthworms and frogs, earthworms and crickets, and so on. And you would find that only the earthworms were eaten. This snake down here in this other cage said, "Don't eat them." Days, weeks go by and they don't eat frogs. The same with crickets and the same with fish. Only earthworms are eaten.

S: Then, from all these observations I have made from my hypothesis... it would mean that the little baby snakes first hatched eat the earthworms because of instinct.

I: Because of what?

S: Instinct.

I: That means we are back to where we are saying it is instinct again.

S: Well.

I: Well, this is fine, but how can you tell it is instinct?

S: As they would'nt eat the other food.

I: Maybe they don't taste good.

S: But they didn't even try.

I: Pardon?

S: But these other snakes didn't even try these.

I: Well you know how a snake tastes?

S: No.

I: Well I think this is the basic bit of information. Their liking it. You have seen large snakes? You know their tongue always is coming out and flicking around?

S: Umm-hmm.

I: All right. This essentially how snakes tastes. The tongue is essential, and the roof of their mouth has a specialized structure called "Jacobson's Organ." The tongue is pulled back in the mouth and up into the roof of the mouth and this gives them the sensations of smell and taste--essentially as we know them. Perhaps we can interpret this about the snake. A snake will come up to its potential prey, put its tongue out, touch it, and put its tongue back in. If the taste sensation is all right then they proceed to eat it. If the taste sensation is wrong--uh-uh.

S: Well, that's what happened in this experiment.

I: Yes?

S: Flicked their tongues out, and the snakes wouldn't eat the crickets. It flicked at it first and found it wasn't agreeable to them.

I: This is an interesting observation. Perhaps a valid one, but it has to be proved. Because how big around is a cricket in comparison to an earthworm? And how big around are each of these things in comparison

with the baby snake, which may only be six inches long?

S: Well, these snakes just don't eat things too much larger. That's larger, you know, it couldn't just gulp in real fast.

I: Well there are sizes over what a snake can eat. I mean, a six inch long baby snake isn't going to eat a frog three inches long, not that the length is so bad but just the bulk. They can't eat it. Well we have introduced some variables here. That is, the size of the prey. Now is there some way you can test; it isn't the taste, or I say it isn't the size, but it actually is the taste of the animal.

S: That it isn't the taste? Or it is?

I: Well, one way or the other. We are concerned with question now of why these little snakes eat the earthworms. Is it because of the size of the earthworm in comparison with crickets and frogs? Or, is it the taste in comparison with crickets and frogs? And what is the controlling factor here? The snake just looks at that cricket and says, "By golly, that's an awful big thing. I couldn't possibly eat that, and I'll go over here and eat this old worm. I'd really rather eat the cricket but he's too big for me and I'll have to grow up before I can eat that." Or, is this the case of the taste situation? And, how can you determine what this is?

S: Well, I could set up another experiment and...putting them in a cage--one snake in one cage, and another in another cage--and having an earthworm in this cage and another one...two snakes, you know, just came over just looking and thinking that they are too big, and smell... I don't know whether they smell or not....

I: Well it isn't a case of their thinking, but obvious reactions to things of different size shows that there is a threshold, if he sees something

that big, it takes off and runs. I mean you have doubtlessly observed this with dogs. If you have a middle-sized dog, it will chase a little one. And each one of its own size, he starts to sniff around some. But if it comes up to a great big Great Dane or something, it doesn't stop to sniff around, he just goes home.

S: Well, if we set up another experiment and kept a careful watch on these little snakes and we put a big fat frog in one and a little earthworm in one, and watched to see if it would go to the frog and attempt to eat it, but then give up and go over to the earthworm -- then I would assume that it would be difficult. Basically on size.

I: Well, but how would you know it isn't taste? The frog and earthworm obviously taste different. If you don't believe this, we'll go over to the biology lab and get one and you can lick each one and you'd probably find that there is a taste difference. And obviously they are different size. So you have a big thing and one taste, and a small thing and something of another taste, and you still have two variables here. Can you think of a way to design an experiment to eliminate one of these variables--or test each one individually?

S: Get a little baby frog and, you know, a little teeny one about like that.

I: All right. We will try to reduce the size.....

S: And if they didn't eat the frog... if he was capable of eating a frog of that size and he didn't eat it, then it would be the taste.

I: All right. But still there is a difference in the shape in some ways of a frog. You can think that you fairly well eliminated size, but you haven't definitely, positively associated this with taste. Well, let me ask you this, did you ever help your mother cook?

S: Yes.

I: Did she ever use any artificial flavorings?

S: I don't know. Yeah, I guess she does.

I: Does this give you any idea of something to do?

S: Maybe to the snake it looked good but didn't taste good....and went over to the one. I don't know.

I: Well, you could design an experiment very nicely. You have heard of such things as vanilla extract that you use in baking? Well, you can make earthworm extract. Or make frog extract. Or you could take a whole bunch of earthworms and take them all and dump them all into your mother's blender with some water. And you come out with earthworm soup. I don't suggest you do this unless you have a very understanding mother. But, you could cut and actually have blended frog, blended fish, and cricket.

S: Yeah and blend up a worm. Then it wouldn't matter what size you know--and if he ate the worm, you know, flicked with the tongue... and the frog or the cricket didn't appeal to him and he went over to this little pile of stuff, which is the worm, and ate...

I: Well, essentially, this is what has been done--to take extracts and dip things like Q-Tips and stick these in cages. And the little snakes will come to the one that has the extract of the prey, which is in this case the worms, and ignore the others. So, on the basis of all this, what kind of a conclusion can you draw?

S: That this particular kind of snake went out and ate the earthworms because of the taste.

I: But is this taste something it learned?

S: Learned? By, you mean, the parents?

I: No--by the little snake.

S: Yes. Maybe on the way....

I: Now, you were talking about this earlier. You said this behavior almost had to be....

S: Instinct.

I: Well now, is instinct learned, or are learning and instinct two different things?

S: It is just there with you.

I: Pardon?

S: It is just, you know... they are with you. I don't make myself too clear.

I: Well, we have instinctive behavior and we have learning behavior. Which is this you see the snakes are displaying here? Instinctive behavior? Or learning behavior?

S: Instinctive behavior.

I: Instinctive. All right. I think that pretty well concludes it.

S: Then by instinctive behavior.

I: All right. Well, very good. I think that will do for now.

Chapter III.

Introduction of the Student to the Task and Problem Situation

The following printed instruction to the problem was presented to each student at the beginning of each interview followed by a printed statement of the problem situation.

> The task you are being asked to perform is to read over an account of events observed by a biologist in spring and summer months on a wildlife reservation near Kansas City, then to plan a way to arrive at a reliable explanation of these events.
>
> You can ask any question which will help you perform this of the specialist in bird behavior, who will tell you what is known by biologists about these questions, but will not help you beyond this. After you read over the statement of observed events here, you can begin to tell about your plans or ask questions.

A male redwinged blackbird is seen perched on a low-hanging bough of a tree near a stream in the spring of the year. Another male redwing flies nearby and is attacked by the male which was perching. The second male immediately flies away.

Later a meadowlark flies into the area close by the tree in which the male redwing is perched. The redwing seems to pay no attention to the cardinal.

Finally, a third male redwing approaches the tree and is driven away by the male redwing which was in the tree in the first scene.

Interview Number 1

Interviewer: Well, what have you been told about what you are to do?

Student: She said there wasn't anything to study, that it would be voluntary--if you didn't want to do it you wouldn't have to.

I: All right, fine. Here is a copy of a piece of paper that has written on it my function here and what you are to do, and secondly, the problem we are asking you to think about. Now, as you have already been told, it isn't a test; it isn't to find out what facts you know. So why not, if I give you a problem...how do you start to think about it? What kind of questions would you ask? And what sequence...in other words, how would you go about solving it? So, if you would like to read that over, and notice that I substituted the word red for spot-wing.

S: So I can ask any question I want?

I: Yes, just relax. Do you understand the problem?

S: Yes. It seems that the first male redwing was affected by the presence of the cardinal. But the bird of the same species, he didn't seem to like him around him somehow. Like, say it was the spring of the year. So that's obviously the reason. And they are all males. Maybe the redwing had already picked out this one place where he wanted to build a nest or something.

I: Well, if there was a cardinal there, why shouldn't this upset the redwing? Why should just another redwing do it?

S: I don't know really. He wouldn't be worried about the cardinal getting his mate.

I: Well, that could be part of it. All right, I think you understand the problem. If you wanted to find out something about this, how would you go about it? One: what could we find out possibly, and two: how would you go about finding these things out? You've noticed this occur in the trees. You say, "Why?" What other things might be of interest along this line, and how do I go about finding them out?

S: I guess I'd have to ask a specialist.

I: Okay start asking him questions now. What would you need to know?

S: Well, maybe there is a difference in the foods they eat. Maybe this place might have been abundanced with the kinds of foods that this redwing liked and so, when he saw the other redwings trying to horn in, he wanted to get rid of them. Maybe he knew the cardinal...I guess they aren't rational...maybe they thought the cardinal didn't like the same kind of food.

I: Okay, you brought out a couple of points. One, do birds "think"? Two, what sort of habitat do these animals live in? So now, how would you find out about this? Do you want to ask me a fact? I'll see if I can answer it.

S: Well, the redwing is a male. The cardinal isn't?

I: No, these are two species of birds.

S: Okay, I just wondered. What does the redwing eat?

I: The redwing is primarily an insectivorous bird. The cardinal, on the other hand, is a seed eater.

S: So that would kind of account for the redwing driving away the other insect eaters. It just seems like he wouldn't want any other birds around so he would have enough for himself. Do redwings live in a warm habitat?

I: The redwings live almost exclusively in the swampy, marshy areas where cattails grow. Now in your own experience you have probably observed the cardinals.

S: Yes.

I: Where?

S: In my own back yard.

I: Have you observed redwing blackbirds in your back yard?

S: Every once in awhile I see one fly by. They don't stick around really. They probably like to be away from people or something. I was just thinking about marshes. They don't have a real solid ground, so that would mean the birds would be closely bunched together and would have to learn how to get along.

I: Why would they have to learn how to get along?

S: Well, they wouldn't have to, I guess. There wouldn't be too many of them then. I mean, there would be...like there is always a struggle for survival.

I: Okay.

S: That keeps down the population. The population is supposed to increase in geometric ratio, and so this would really keep down their population because they are in such a small area. Grouped together, they would always be fighting among themselves.

I: Okay. But now you might pursue this thought for awhile. You are perfectly right in what you said. But think about every day what they would do in

terms of survival. In other words, break down this idea of survival. What could you investigate that would be important to these birds for survival?

S: Probably shelter. Shelter, and how much food they had. Their enemies, or what is in that area that could harm them. That's about all I can think of.

I: You talk about population. How does the population decrease?

S: Well, there would be food shortages.

I: Yes, but how? Specifically. How do birds reproduce?

S: By eggs.

I: Do you think this might have anything to do with it?
Do you think there might be any competition among birds, say, where they might lay their eggs or go home to mate?

S: Yes, and that would probably be why the other redwings were driven away. Maybe that was where they had kind of a meeting place, where most of the female birds came to, and maybe he wanted to guard it or something.

I: Do you want to ask any factual questions?

S: Where do they like to mate? Or where do they like to build their nests?

I: Since they are in marshy situations, they can go among cattails.

S: On the ground?

I: They are low to the ground, anyway. Incidentally, here is the bird we are talking about. And that's the female.

S: They seem to have a bad temper.

I: They are very feisty. They attack sheep, cows, men, horses.

S: I know. Over in Dunn Park, we lost a tennis ball back in the bushes and one of those dumb birds had a nest back there, and he kind of dived at us.

I: It might interest you also that the male redwing takes serveral mates all at the same time, and on this territory.

S: So they would seem to be, since their nests are so close to the ground, always be attacked by some kind of an animal or something, like a weasel or something like that, or an otter maybe in the marsh, or maybe they live in streams. But I don't seem to be getting anywhere answering this question.

I: You are doing very well. But I am saying that I want you to prove these things to me. How would you go about proving it to me? I want you to give me some data, and say, "look this shows what I'm saying."

S: The first tree shows that the male redwings don't like each other.

I: But how would you prove this to me? Not by just what is on the paper. This is your problem. This is what you think about this situation. Now prove it.

S: Well, prove they don't like each other, or prove they were in their mating area?

I: That, and everything that you can think and have been thinking about.

S: Just the fact that he drove them off, doesn't answer that. So he was on a tree....

I: Now wait a minute, I think you are misunderstanding me still. I mean that what you are saying here may or may not be true. Now I am saying, here is the problem; how would you go out and actually collect data and bring it back in and say, "I have observed this and this and this." Or perhaps set up an experiment. Do you see what I'm getting at? How would you go about doing this?

S: Well, it doesn't say what kind of a cardinal it was.

I: Well, that doesn't make any difference.

S: But you might try what it has to do with the different kinds of birds to see how they react. Like you might try to see what they do with the different types. Like you said with the redwing. They reacted violently and tried to chase it away. And then see what it does with the female redwing--if it does fly up. Then try a cardinal and see what it does. But like you said, the cardinal was a seed-eater, and the redwing was an insect-eater. So these two wouldn't want to rob each other because they didn't eat the same food. And where do cardinals build their nest? In the trees?

I: Low, bushy areas. Hedgerows for example. But definitely in dry areas.

S: It seems like he would have been more apt to drive off the cardinals since...well, I guess he isn't in marshy areas now. He is in a tree, right?

I: Yes, one would get the impression that he is out of his own environment.

S: Well, he is probably a stranger in this environment isn't he?

I: Yes, I think we can assume that.

S: Well, then he would be protecting himself. You know, he would be on guard, really, if he attacks his own kind.

I: Well....

S: It seems like he would want to have somebody, some of his own species there with him, and when he sees this cardinal--something he hasn't seen every day--it's kind of new to him.

I: Well, would you like to phrase a direct question to me about this?

S: How do the redwings react in a different environment?

I: We could assume that since this is the breeding season that, even though they aren't in their own territory, they still are going to act as though they are to a certain extent. Especially with respect to other males of their species. Have you considered how a redwing might react to another insectivorous bird rather than to a cardinal?

S: Like a bluejay would be one, wouldn't it?

I: All right, let's say a bluejay.

S: Well, how would it react? The bluejay is kind of a scavenger, really. But how would a redwing react to a bluejay?

I: Well, I would say that it would be the same reaction as to the cardinal. But how can you prove this?

S: You would have to get a bluejay for an experiment to see how a redwing reacts to the bluejay or to another bird.

I: How would you construct an experiment to show this?

S: Probably you would have to have a cage, first off. So you would have two brooders together. Then you would have to catch a bluejay and a redwing and see how they react to each other--if it were violent. So that would mean it wouldn't be anything about food. If it were negative...if they didn't attack each other....

I: What would you do about offering them food? We would assume that you would have to feed them and keep them under as normal circumstances as you could.

S: I would just have one place where I would put the insects, and see which one goes for it...if they both go for it and get in a quarrel or something like that.

I: What about the possibility that maybe the bluejay would rather have something other than insects?

S: Well, what does a bluejay eat?

I: Specifically, I can't answer your question. I think you will find that scavengers will tend more toward insects. I'm taking this as a hypothetical example. Let's say we don't know what the bluejay eats.

S: Well, we would have to find out what the bluejay eats. I guess we would first have to take the bluejay and find out what he likes bests, and say we know that the redwing likes insects best. First off, we would put the kind that the redwing likes best in, and maybe put in what the bluejay likes best. And then, you know, if the bluejay goes for what the redwing eats, the redwing would react to it and try to fight the bluejay off. Then, maybe when the bluejay got the food that he normally likes, if the redwing went for that, they would probably get into a quarrel. Then put both kinds of food in there and if each one ate without any controversy, but just kind of peaceful, then you would know that it would be over the food they had. That's why they were quarreling in the first place, or why the redwing....

I: All right, fine.

S: I'd try a different kind of bird. For example, a bluejay rather than a cardinal. If nothing happens I would conclude that the fighting among redwings was caused by mating or protection of territory. If they did fight I'd say redwings just don't get along with other birds. In a tree the redwing is out of his habitat, which is marshes. I'd put a redwing in a marsh and bring in other birds to see what happened. If the redwings fight in the marsh I'd just say they were a natural enemy of themselves. But it may have been mating season. I'd bring redwings together in the marsh in different seasons and see what happens.

Interview Number 2

Interviewer: Now first of all you aren't expected to come up with any facts. That's my job. The object is to give you a problem cold, one that you haven't thought about before. About this problem, you will have questions. You need to know some facts to work on it. That's what I'm here for. That's what these books are for. I'll try to answer any questions you have. We want to present you a problem and see how you think about it. In other words, you have posed here this situation as though you walked out in your back yard and it was something that you saw. First of all, you would ask yourself a question, "Why?" And also, "Why does this particular thing occur?" You might form a hypothesis that you must answer in your mind about this. What we want to know is how you would go about proving this hypothesis? What kind of questions would you ask and in what order? How would you prove these things to me?

Student: I guess it is talking about one species of bird that drives off birds of the same species—they are both males. Another species of bird, it doesn't even bother. I don't know much about birds or anything.

I: That's one point. Do you have questions about birds? Several questions? Ask me.

S: I have one good question. Why am I here?

I: Just simply to find out, if we give you a problem like this, how do you go about answering it? This information is being gathered in order to improve courses in high schools, and textbooks, etc. Are you getting the kind of information that you need? In other words, how can you think deductively?

S: The problem is that I don't know whether birds have nesting rights or something like that.

I: Yes. Yes they do.

S: Well, do they just have the rights over their own species of birds or over other species?

I: This is a relative thing. It is very strong among males in their species in the same population.

S: So it looks like the way I'd go about it, I think I'd first of all watch the birds more. Especially if they were out in my back yard or something. If the same male bird kept driving the same species away, I'd watch this and see if they didn't drive other species of birds away. And that's about all I could do.

I: Well, let's carry it a little bit further. Might you ask yourself why these birds are fighting?

S: Well, I think I've already recognized what the problem is. It seems to me the one bird had claimed a certain spot for himself. He didn't see that other birds of a different species were of any harm to him, like the male of his own species.

I: Would you like to break down what this harm or danger might be? In other words, what's the problem? You've got a territory; so why does he defend his territory?

S: Well, I don't know. I guess it's instinctive of this bird. Either it's nesting time and he wants to find a place, or he wants this territory. Like he's got squatter's rights or something on this spot from the same species.

I: What does this bird do in this territory? What is it that he is so possessive about? How would you go about doing this?

S: I've observed him. It would be about the only way I could. The same circumstances wouldn't come in a different environment. He would have to be left alone and just watched.

I: Do you have any ideas in your mind, right now, as to why birds protect territories

S: Probably because, you know, just like human beings they figure it's their own. They don't want anybody of the same species to bother them or even come in. They may not mind other birds. I don't know why, but the same species, they just don't want them in.

I: All right, let's pose a specific problem. We are talking about redwing blackbirds here. The redwing blackbird nests in marshy areas. The males have territories and are polygamists. They take several mates every year. These are facts. Now, let us say that you are out sitting in a marsh watching the redwing blackbirds. What sort of things would you imagine you would see these birds doing? What is he doing for his daily existence?

S: If he has got his own territory, I imagine he is eating, for one thing. If he is looking for mates, he is probably keeping close watch on any other birds that come into his territory. Mostly he is scouting for food. It probably depends on what time of day it is. Even if he is keeping an eye on mates, he always is keeping a watch out for other birds that might come to take his territory because if he does acquire more than one mate, there could be another male bird of the same species trying to get in and take his mate away from him, so he would have to protect everything he had. And also, he is probably protecting the food that is around his territory. He has to keep that in mind.

I: You say, "Probably, maybe." Okay. These are very good working hypothesis. I could sit here and say, "Yes you're right." But now that you have said all these maybes, how are you going to show me that these actually are the facts?

S: Well, if I were going to undertake a big study of them...if I had the money or anything....

I: Let's assume you have all the money and everything you need.

S: First of all, I would enclose an area in which I could control the birds that went in and went out. I would let the bird take on mates. Then I would put in birds of other species in the same enclosed area and see. I don't want it too small because it wouldn't be the same environment that he was living in. But if it were a big enough area, you could put in birds of other species and you would be able to regulate which bird went in and out. You could put those birds in and, if he fought these birds, the hypothesis would be shot down. But if he didn't bother these birds at all, and you put in male birds of the same species, and he

attacked these birds because they were trying to acquire mates or trying to get at his food, this would tell me that the redwing blackbirds attack other redwing blackbirds because they are possessive and want their territorial rights.

I: Okay, have you thought about the male-female relationships? In other words, is there any circumstance where the male bird might attack a female? Or do you think this would just be limited?

S: I think that would be limited because in most species of any kind, the male doesn't usually attack the female. I haven't seen any instances where the male would attack the female.

I: Male redwing blackbirds will attack females outside their breeding season. Since they are polygamists, and we have one male right here sitting on his territory with x number of females, and presumably he chooses mate number one at one time, and just like all women, they are going to be spoiled, and so mate number one interferes with his getting mate number three.

S: I don't think he would attack her, but I think he would set her straight. Either conform or get out.

I: All right, very good. Now, can you think of what you might do with this information? First of all, you've designed a beautiful experiment. Could you break it down further into other smaller parts to work on smaller problems? This is a big problem.

S: Well, in order to make it smaller you would have to change the environment because, if you are out on a marsh, it would be huge. But you could take a redwing blackbird and watch him in mating season with a female. If he did attack her during mating season there would be another problem there. But if he didn't attack here, it points to the fact that nothing was wrong. You could also....You can't capture them and study them because it wouldn't be the same environment and it wouldn't be a true test, so it would have to be over a large basis, I think.

I: What about the possibility of doing both?

S: Well, you could still do both, but like I said, even under a captive state they wouldn't react the same. From what I've read, they don't exactly mate or reproduce or anything like that as well in captivity as not in captivity.

I: Yes, there's an amusing, ludicrous sort of thing called the Harvard Law which means the animals will do anything they please in captivity. Sometimes we can't avoid working under these circumstances, but when one tries to make observations in the field, and possibly do things in laboratories simultaneously to see what the difference is, if any, to find out how good your experiment may or may not be....

S: I think you have a point there, but I think also that if I were observing the birds, I would also take pictures and write down the kinds of things like that so I could be able to tell one bird from another bird. So I would have to band them or something like that after I captured them. I would have to capture a few of them.

I: Do you think it would change their behavior if they were banded?

S: Not the banding. I don't think that would change their behavior because they would still be in their wild state. I hunt once in awhile, and my dad has shot banded geese. I don't think it would affect them because they wouldn't be aware that the band was there, and we could tell which was which.

I: You mentioned something about photographs. Why would you do this?

S: If a male bird was attacking another male bird of the same species, I'd photograph this and write whether they were attacking each other for a real reason...why they were attacking each other. Then if I caught two females fighting, I'd take a picture of this, and write why I thought it was. Anything that seemed significant, I'd classify and study.

I: Do you think, possibly, that the ages of birds might have anything to do with this?

S: I sort of doubt it. The only significance I think the age would have is how well they could fight or defend their territory.

I: I might interject here, the redwing blackbirds usually do not breed until their seventh year.

S: So, I guess you would have to know how old they were too, some way.

I: How would you do it?

S: If I were going to make this large study, I'd band some baby birds. That way, over a long period of time, I would see if they bothered or fought with the male, or an older male, during mating season. If they didn't, you would know that this corresponds with the mating season, and that was the only reason they fought.

I: What else can you think of that might be important here?

S: I'd also see what foods they eat.

I: How?

S: How? Well, first by observation--to see what they did eat, and what times of the year.

I: Again, do you think that within a population there would be any differences? Especially in what they ate?

S: Do you mean...?Well, it would depend on what they ate, where they were. Like out on the marsh. I don't know whether they are different from the foods of other species of birds or not. I imagine they would be about the same thing.

I: Just phrase a question and ask me as if you had to go look it up in a book.

S: Do the redwing blackbirds eat the same kind of foods as other birds?

I: No, they are insectivorous. We have seed-eaters; we have birds that strictly eat insects. Okay?

S: So what do they eat? Everything?

I: They eat everything that...insectivorous mean insects.

S: Just insects?

I: Yes, they go out in the woods and search.

S: They don't eat grain or anything like that? That would limit it a great deal then if they just ate insects. You could tell that they were fighting over the territory because it was by a cornfield or something like that. That wouldn't have any significance. That could limit the food supply a great deal, unless there were a whole lot of dead trees in that spot or something like that.

I: All right, great. You've looked at the problem and you've said, "All right now, I have x number of things which show what's going on." Now, after you've shown on paper what's going on and you've photographed and described it, what do you think you'll ask about the function of all of this? In other words, why would you be doing this?

S: Mostly, if I were doing it, it would be out of curiosity. I don't have any other big reasons for doing it unless I had a job to do it. Unless I just wanted to know.

I: But essentially you are describing here something called territoriality, which you are probably acquainted with. Why territoriality? In other words, you are all done with this. What is the significance of this?

S: Well, to me, just knowing is the significance. But I imagine that biologists or conservationists...to see in a way that the birds were becoming extinct or something like that. It might show reasons why the breeding was being disturbed by civilization or something like that.

I: You hit on something there. You said that it would be important to biologists. How do you think this would be of importance to biologists? In other words, I am a biologist, but I'm not interested in birds, particularly, but am interested in something else. If I pick up your paper and read it, what would I get out of it?

S: I don't know what you would get out of it, but....

I: In other words, what makes this important? Out of the sight of just birds, and describing their behavior of this particular species of bird, do you have any ideas?

S: Well, it is important in the fact that to know it would be important. Also, it is important that these birds could be a giant study. They could be disturbing other birds. This same bird could be going extinct. We are looking for reasons to find out why and what we could do about it.

I: Do you have any idea what the idea we've been talking about is? What kind of study this is? This particular problem, what kind of study it is?

S: I don't know. I guess it's....I don't have any idea.

I: Behavior?

S: Yes.

I: Okay, it is. We have investigated this whole idea of fighting. Is this the only aspect of behavior?

S: No. There could be the mating aspect. You know, the procedure in which the birds may do anything like that. The way they go about finding their food.

I: Do you think any of these would interact with one another?

S: Well, I think the main reason is because the male bird was always.... The way he found his mate was taking from other birds. That would be one main factor why they are always fighting.

I: We have points within the species. We forgot the cardinal aspect. You might think about that a little while and tell me what you might do with that. How do you think this fits into the picture?

S: Well, as I was discussing before, it seems like the blackbird doesn't have any fear or any reason to be concerned with other species of birds, because probably they wouldn't mate with the blackbirds. So he doesn't have any fear or reason to fight them because only his same species would mate.

I: Do you think it is just a matter of mating?

S: Again, it depends on the territory. If they are in a marsh or something like that there would probably be insects all over, so there wouldn't be any reason to fight, unless it was over one particular tree. I guess predators would be the only thing that would actually kill the birds, unless it would be poisons or something like that.

I: All right, this is an interesting point. But now say that they are both eating the same food.

S: Did you say there wasn't enough food, or there was?

I: They are eating the same amount of food. Today there was enough for the number of birds, but tomorrow there wasn't.

S: Well, if the population kept rising and rising, that would be the only way that could be...after so many years there wasn't enough to serve the population.

I: In other words, you think the fighting may actually be beneficial in a way.

S: Yes, but this is not a factor because they just drive them out when they do fight. I think that probably the predator affects their mortality rate to keep the population down to a certain minimum, unless they took away the predators, and this would cause it to rise.

I: All right, we have talked about density as a huge problem in itself. We have two problems here. Can you see what they are? First of all, assume that we have two different species of birds.

S: It seems that there are a larger amount of male birds in the territory than female birds.

I: How would you go about proving this?

S: I would regulate the number of birds that come into the area.

I: What specific thing would you like to show here?

S: Well, I would take special attention to the season that the birds were fighting in--if they were in the mating season, or if they were fighting out of the mating season. This would cause another problem. It could be over food or territorial rights.

I: You brought out another point when you said that the birds very seldom kill each other when they fight. Do you see any reason for this?

S: Mostly when they fight they are trying to bluff another one. They are making a big deal out of it, and when the going gets rough the weakest will take off before he really gets hurt.

I: Have you ever watched a redwing, or any other species go through this, and then at another time watch another bird of the same species do the same thing?

S: Do you mean to watch a bird fight and then run off, and then watch him another time fight till his death?

I: No, I mean just to watch the sort of sequence of fighting of two different birds of the same species at different times.

S: Well, I can't think of any time when I have.

I: Well, you've noticed then that all birds of exactly the same species fight exactly the same way?

S: Oh, you mean do they fight in the same way?

I: They have a series of style-like movements to go through this business.

S: Just like some birds when they mate. They really strut around and all that.

I: Exactly! Now, do you think that's important?

S: Well, I guess that's just a matter of the bird.

I: Do you think this is important though? Is it the bird? Is it the individual? Is it the way you do something, the way I do something, or the way we all do something?

S: I imagine it's a trait of the species. They go through this process when they mate. That's to help you realize when the mating season is.

I: If you were going through this business of photographing, what would you do to handle this aspect of it?

S: So I think it is important that they do this to mate?

I: Not that it is important that they do that except in relationship to your study.

S: Well, I imagine that if I were studing during the time of mating season, it would be significant in that I could tell that they were mating. Then when they went through this process before instead of out of the mating season....

I: Do you suppose you could tell anything about the behavior of a given bird by the way he acts? How could you tell if he was getting ready to mate or chase this other guy off?

S: Ive seen on television that the birds act a certain way when they are going to mate, and when they fight they act a certain way. You could take pictures of these and study them and watch the birds after you already have the picture, and you could tell whether they were going to mate or fight.

I: As you look back over what you have said and thought about, would you change anything? Or how would you approach this problem in a very simple one, two, three fashion?

S: Well, I wouldn't change it so much. I could probably organize it better. Like when I started this study, I'd first start by enclosing an area for studying the birds. Then I would photograph them at different times of the season. I would also study and photograph different species.

Interview Number 3

Interviewer: We are not interested in the facts you know. That's what I'm here for. If you need a fact, ask me. We want to know how you go about finding out what this means. How do you design an experiment? What do I do? One, two, three. Okay? And then, after you have done all this, what sort of conclusions could you come up with?

Student: So in other words, you want to know the way we find the solution?

I: Right. I want to know how you think about it. That is what the research center wants to know. And the whole point of this is that we can take this information you and all these other students give us, look at the way you think, and say, "All right, are all of our biology teachers in high school coming through? Are they teaching these people how to think? Can they see a problem?" You just ask me anything you want to know. It might help, first of all, to define just exactly what's happening.

S: It seems as if the first redwing bird is in a tree, and he protects that tree and his surroundings from any other of his own kind.

I: What about the other bird mentioned there?

S: I guess he figures that he is not his own kind, so he isn't a threat.

I: So this is your hypothesis? This is your problem?

S: Yes, I suppose so. I don't see exactly what you want us to find out though. Do you want to find out why he only protects and drives out his own kind and not the other bird?

I: Yes, and I want an explanation of this behavior.

S: Well, is the redwing bird a very big bird?

I: Bigger than the cardinal, but not too much. You know what size a meadowlark is? A redwing is roughly the same size.

S: Well, he is just going to protect from larger birds or from his own kind. So, in other words, because the cardinal is smaller, he might not see the cardinal. Do they ever get eyesight for size?

I: Oh yes, birds have excellent eyesight.

S: So then he would see the cardinal, and he would know from some past experience that the cardinal would be no...,that he would be a fool to come and attack him because he would be outclassed. So why should he drive him out? Because he is not...there's no fear. But when he sees one of his own kind, he has to drive them out right away or he is going to get taken. Maybe he would do this to a larger bird, or maybe he would just leave them alone and only drive out his own kind.

I: Now, where would you go from here?

S: Well, you would have to take and sort of isolate an area or something. Anyway, put in a larger bird and see if he drove him out. And then put in another redwing and see if he drove him out. And maybe do that two or three times to see if the same thing happened. And then try it with other birds. And after you found out, either you get the answer that a male will protect his habitat from all birds larger or the same as he is, or he drives out all birds larger or the same size he is.

I: Would it occur to you to wonder why he is driving out any bird?

S: I guess you've got to figure that is where he plans to live. Do they nest?

I: Oh yes.

S: Maybe he figures that is where he is going to put their nest. It's the same thing as if somebody came up to your house, and you drive them out.

I: What other aspects would be involved in this?

S: Well, you could see if he would drive out....Do they mate with just one bird a summer?

I: No. Redwing blackbirds nest in marshy areas--swamps. Let's assume that our swamp has a tree. The males are migratory and they fly to their breeding grounds. They arrive there every year at the same time. Males will set up territories. They take several females at the same time, so there will be several nests in one male's territory.

S: Then that could sort of explain your problem. It might have been that since another male came in....You know, it's like if you owned a section of land and somebody came in and sort of tried to take over your land. You would drive them off. This was the first redwing's territory. So the second one came and the first redwing wanted to get rid of him. Or it might be that he is protecting his own territory from any bird, either of his own species or larger, and you would have to experiment to find out.

I: Okay, how would you do it?

S: Well, you would find first....Can you sort of tell where the territory of one begins and one ends?

I: Yes, this is something I would like you to tell me about how you might do this rather than my telling you.

S: I just wondered if you could.

I: Yes, it is possible.

S: So you would mark off the area, and to do the experiment right, I guess you would have to control it. You would have to try to block off for only the birds that you want to go into it.

I: How would you establish where his territory was?

S: Well, after observing the birds and the way they live and move around, then you would be able to tell if they kept coming back in the same couple of trees.

I: First of all, what would you do?

S: Observe.

I: All right. You are out there and you can see just what you are mentioning. How would you go about knowing just exactly? Is it a matter of just a tree? Or maybe the bird has several square feet around this tree that is his territory?

S: I don't know, unless you rationally looked at the trees. If they were ten feet apart and one bird nested in one, and another bird nested in the other, you could maybe figure that there might be sort of an imaginary line that would be an agreement between the two birds. Maybe they knew where the other one was supposed to go.

I: Do you suppose you could tell just by watching the birds? Say you could draw a line on a piece of paper, and say here is tree one and here is tree two, and this bird never crosses over here?

S: Yes, if you watched. In the first place you would have to set up where their trees were, and then you would have to set up in between the trees. Then you would have to sort of put up a line and watch the birds to see how far over it they came and mark that with maybe a survey deal. And then, see how far the other bird came over. Then, you could tell after watching a long time, maybe a couple of months or something.

I: Do you suppose you could find out anything about people who have done studies like this before? It might give you an idea.

S: Yes, there would probably be studies you could go to, maybe at a noted university, or a professor, or somebody that could give you some information and some books.

I: Okay. We are trying to establish the birds' territories, right?

S: Yes, and after you have found out how far each bird goes over toward the other bird's territory, then you could pretty well establish almost exactly what his territory was. Then, what you would have to do is an experiment to control it. You've got to somehow mark off a free territory. Then let in one bird at a time when no other bird could come in his territory other than he and his mate. Then let in one bird larger than him and see if he drives him out. Then let in one male of the same species and see if he would drive him out. Do this, and then let in another bird, maybe even larger, of a different species than you had the time before. After doing this, maybe you would do this to a bird that has a territory right next to his. From that, you would go and mark off the other bird's terrotory. After doing the first one, you would have a pretty good idea where his territory was, if you didn't already know. Then, you could do the same thing again. After a whole lot of times you could figure out whether the redwing, during his mating time, is going to drive out all male redwings from his territory, or whether the redwing bird, during the spring and the mating time, drives all birds from his territory plus all male birds from his species.

I: Okay, that's good reasoning. Now, there are a couple of other ideas you might be interested in here: Why do they drive birds out?

S: If it's during mating season, I guess as a protective motivation of the father, because in a way he is protecting his children even though they are still eggs. Also, the birds that he mated with....He would drive out the birds for a protective reason.

I: What else does a bird or any other living thing do? Think of some of the very simple things we do.

S: Well, we are possessive about our house. In a way, that's half of his home. If we didn't have any kids, and if somebody came and tried to take the house away, even we would give him a lot of trouble.

I: I was thinking about food. I wondered if you considered this.

S: Well, no I haven't. Yeah, I didn't think about that. Maybe he thought he had a good territory that had a lot of good places to get food and these other birds tried to come in and steal them, so that's why he drove them out.

I: What do you think might happen at other times of the year?

S: I guess at another time of year you would find out whether he was fighting just because of breeding season. If he didn't do it at any other time of the year, you would know that it was just the protective sense of the father.

I: If you were really planning this experiment and I asked you to submit an outline to tell me what you were going to do, there would be some facts

you probably ought to know. Like redwinged blackbirds migrate, so they wouldn't be here during off-seasons. What do we do about the females' present behavior? Is there any?

S: Where do they migrate to?

I: South.

S: Just south?

I: There is a place they go to I suppose, but right offhand I can't tell you where it is. How would you find that out?

S: Well, you would probably go to a university or a professor noted for bird knowledge and ask him where the redwinged blackbird goes. If you did the first experiment, you would know what kind of birds they drove out, but you wouldn't know whether they did it out of a father instinct or whether they did it out of fear of getting their food stolen, or something like that. So you would have to control those two things. You couldn't do it during mating season because both the things are open: They need food and they have the father instinct at that time. So you would have to do the same thing where they migrated--when there is only one possibility, because at this time if they drove out other birds, it would only be for the protection of keeping all their food.

I: Have you given any thought to what the bird actually does? We say he fights off the nest. What does that mean? I mean, it is not fist fights.

S: But if you saw that it drives off the other male, you would know how he did it. Maybe he would go and peck him, or something like that.

I: And how would you determine these things? How would you find this out?

S: Well, when you let in a bird you could see him drive one of the birds out, whatever kind it happened to be. You would see what he would be doing, whether he pecked at him, or knocked him off the tree. Clawed him.

I: Well, we have some rather stylized and ritualized behavior. We are saying that birds in the same species will act in exactly the same way. They don't really come to blows with the bird. They go through the process of putting their wings and heads up, and they will flutter their wings and crouch down, all of which is just as annoying to the other bird as if I came up and punched you right in the nose. But I'm just wondering if this would seem important to you at all.

S: Well, I figured that it would seem so, and since you would have seen him twice, you would know what he did, whether he made a high pitched noise or....

I: Well, would you do anything about this after you had observed it? Would this be a part of your study?

S: I don't know. In a way, I guess the contrast between the way....Unless there was a difference between one species - if they fought off other birds. Were they different?

I: A given species will always fight in exactly the same way, but different species will go through different actions.

S: Like a cardinal against a robin - they fight differently than a redwing against a cardinal?

I: All cardinals will fight alike and all robins will, but on top of this we have females that will act slightly different than males. Do you think this might have any importance?

S: Not really because the whole experiment was just concerned with males. There was nothing even about females in the thing, much less driving out any.

I: Would the male react to a female lighting in the tree? This might be something worth finding out. Can he tell the difference?

S: But if he mates with more than one female at the same time, he is bound to know at least something, whether it's a male or a female because, if a male comes in and he drives him off - the female comes in and he is going to mate with two or three of them, he is bound to know.

I: Do you think the postures they assume may have anything to do with it?

S: Yes.

I: So therefore, they might be important?

S: Yes.

I: See what I mean? The thing is, if you felt this was worthwhile describing, how would you go about getting the information to describe it?

S: During mating season you would put in one female redwing and just see exactly the postures and the sounds that both birds made toward each other.

I: Do you have any ideas how you would record this? So you could study?

S: You could take a movie of it and then keep going over the films like they do for football or something. Just keep watching and going over them.

I: Sure - same exact thing except instead of watching the quarterback run down the field, you're watching some silly bird run along a branch. Same exact object. Okay. You've covered this as far as an individual bird goes and you've done a good job. Now, do you have any other ideas? What else could you do with this?

S: Well, you could then put a cross section of birds, maybe either of the same species, maybe five of them, in each of their territories and see what happens or you could have many birds, maybe ten different species and do one to see what he does, and then the next species, and then if you filmed these you could study them and see the contrast between each one and the similarities between each one. What the redwing does when another bird comes into his territory - if he drives him out by making a certain motion and the cardinal when someone comes into his territory he drives him out by, maybe, making a noise sounding like a horn or something. And you'd say the similarities...well, both of them always drive out the male or both of them take a certain position when they have a female come into their territory.

I: Right, now what do you think the significance is of this? Let's say you did ten birds and five of them had essentially four movements that each made. Let's say five of our birds have the first three movements all the same, whereas the other five may have movements completely different.

S: Well, then, the first three or four birds that had exactly the same movements...first you'd have to look into some place with research and see how they were related with other species, etc. And then, that might answer your question right away.

I: Do you think the behavior of the birds is what we're talking about, might indicate their relationship somehow?

S: Yes, it could either indicate that maybe their habitat...maybe they live in the same part of the country. It could be they have already determined down through evolution and they are very close or they aren't - that's what you could determine. And I don't know how you'd do that. How would you go about studying?

I: We call that study systematics and the thing about that is it takes every kind of character you can imagine. It takes the appearance of birds - how their head combs are put together and their wings put together, what kind of calls they make. Their size, color, shape, everything, plus their behavior. It takes them all into account and says, species A is so similar. You know, 99% of these characteristics are the same so these must be closely related or as you have pointed out very acutely, perhaps they have evolved from two different places - two different lines, two sets of parents, but they've been in the same kind of situation, habitat, for over a number of years. Maybe, the same kind of habitat may be in North America or in South America and consequently they've evolved where they are almost exactly alike today. So, behavior is just one small part of this business of systematics and a very important part. That's what I was trying to bring out of you - to take all of these little things to see how they act, what they actually do. We need to know this for each species - and so this has evolutionary significance, besides all the business of what's actually going on here. So it's not as insignificant, this little drama we have here, as it first seems.

S: Yes, I see.

I: Well, what else could we consider here? Anything occur to you? What else might you do with this sort of thing? One thing you haven't done at all is why this territory - we talked about food, nests - but what else is obvious? Remember, we have a population of birds in one place, essentially.

S: It makes sure no one bird becomes too much of an aggressor.

I: Keep going.

S: This way there are many different changes that continue evolution. It continues it because, maybe, one bird has a slight difference than another, cause there's always differences in species. One might have bigger wings than another for some reason, and it might be something he just didn't acquire because of some crossbreeding. He would pass this down and many, many years after that a new species would come about.

I: You've given a lot of thought to different aspects of this problem. Can you go back and since you've had a chance to organize your thoughts, provide an explanation for this particular problem? What exactly would I do? One, two, three. What is my purpose for doing these things? What do I want to find out?

S: In the first place, I would narrow it down. Because I figure if you went around every possibility, you could be dead three times and still not know. So, first thing to do is find out exactly what you want to find out. Do you want to find out whether the redwing bird drives out only its species, male species? Or do they drive out, not only its species, but larger birds that might be a threat to them? What it did when females came in, in contrast to males. What a cross section of birds did, and then see if various related birds were significantly the same. And if so, then trace them back and see if they had common ancestors or common habitat. Or would you...I guess that's all.

I: What would you do in terms of the nitty-gritty like first of all, I've got to do what with this problem? What's the A-No. 1 thing you're going to do once you've got your problem?

S: First collect all the past research I found so you don't find something someone found 100 years ago. Find out all the predictions in this problem of past hypotheses and see so that once you're done you'll know if your hypothesis supports this guy's or this guy's. Then, you would set up a controlled instrument on whatever the exact problem you were going to do. Then control it, one possibility at a time until all your possibilities can be concluded and then you'd say, "From my experiments I have found out" - then say exactly what you've found out and what you'll predict will happen. Then you can relate what you found out to

whether it completely blew his theory. I suppose then you might be famous or something like that.

Interview Number 4

Interviewer: The whole object of this is not what you know in terms of facts. That is what I am here for. Anything you need to know, any questions you have--and I hope you'll have a lot of them - ask me, and I'll try to give you the answers. In other words, it's just like a computer situation - you ask the computer a question, the computer gives you the answer. What you do with the answer, then, is your problem. We are going to give you a problem, something to think about, and we are going to ask you to 1) define the problem in your own mind - make sure you understand it and 2) how would you explain this problem? And of course, by explaining this means setting up an experiment, examining your questions in a logical sequence. First by saying, I could find this out, and then maybe I could do this or do this and this would tell me something else and from here I could go on the last aspect of the problem. Okay?

Student: Okay, now do you want me to give you things I think are necessary to try to solve this or do you want me to just start asking questions?

I: You just do it any way you're comfortable - any way you want to.

S: But the object is to try to solve this case?

I: Yes.

S: I guess first of all you'd have to find out how these birds react to one another. Maybe they have something against their breed.

I: Are you sure you understand your problem now?

S: It is that the one bird that was there first is attacking all the birds that come?

I: If you read it carefully, you'll notice that it says that the redwing blackbird is present, and there is a cardinal.

S: And when the cardinal comes to the same tree the redwing attacks it?

I: Read it again. Make sure you understand.

S: Well, it seems that the first redwing is attacking any other redwing bird that would come, but he doesn't pay any attention to the cardinal.

I: Fine.

S: Is that it?

I: That's a paraphrase of what it's saying there.

S: Okay. I can't see any reason why he would attack the other redwing birds unless the cardinal attracted the three redwing birds and for some reason the first one didn't want him around.

I: I think you can safely assume that the first one doesn't want the second one about. Maybe what you need to do is find out something about birds by asking me some specific questions.

S: Oh, are you supposed to know all of this?

I: Yes. That's why I say, any questions you've got like do redwings do this or do cardinals do that, or what do redwings eat, I'm supposed to be able to answer for you.

S: Okay. What's the relationship between the redwing bird and the cardinal?

I: They are both perching, singing birds, but of two different species. They're not closely related. Now I'm not going to tell you any more than you ask me. So you just keep your questions coming fast.

S: What sex was the cardinal?

I: Unknown.

S: Since the redwing birds were all males, maybe that's why. The cardinal might be a female - or do they do that?

I: Are you trying to ask me whether the redwing might breed with the cardinal?

S: Yes, like for some reason the first one wouldn't want the other two around.

I: What would happen if you crossed a redwing with a cardinal?

S: Well, I'm saying I don't think they do that, do they?

I: No, they don't.

S: Okay, then that couldn't be it.

I: One might ask what keeps them from interbreeding. That's something you might think about a little later on.

S: Do you want me to come up with as many questions as I can, or do you want me to....

I: Ask me the questions that will help you.

S: Well, as long as I know that couldn't be one of the reasons, why ask why? I mean, that's just getting into another problem.

I: You might come up with that later on.

S: Do the birds of the redwing species usually attack one another like that?

I: Yes - males.

S: Just the males?

I: Not always, but it's more common among males than females.

S: You don't know anything else about the relationship between redwings and the cardinals?

I: Yes, what specifically would you like to know about their relationship? Are we talking about differences in food habits, differences in the place they live, what? You see you have to narrow your question down as if you were looking it up.

S: Okay, what is a redwing bird, anyway?

I: You've probably seen them. They're about that size. The males have red on their combs and tops of their wings. The female is kind of dull looking. They're ugly except for their colors.

S: Do you know if there was anything on the tree that would attract the birds, or why all of a sudden there were four birds coming to the tree?

I: I'll just have to give you a hypothetical answer. It could have been for food.

S: You don't know?

I: In this particular case, no, but food might be one reason they were all there.

S: Are we saying the one male was just sitting there?

I: Yes.

S: Perching doesn't mean anything else besides that?

I: No, just that he was sitting on a limb as if he were there for awhile.

S: Why would the second one fly away right away? Why wouldn't he just stay there and fight back?

I: Perhaps, it wasn't his territory.

S: What do you mean, his territory?

I: All right, birds establish territories - male birds in particular during the breeding season. This means this is an area of ground which they are commonly found on and which they will defend.

S: For what?

I: What do you mean, for what?

S: Well, for what purpose? Why would they defend that one area?

I: Could it be because they have nests on that area with females incubating the eggs? Could it be because they have food in that particular area? Any number of things.

S: Is there any other reason--let's say if there was another nest there, the other males that were flying there - is there any reason they would be doing that? Are they flying there to the nest for some purpose?

I: I would have to say probably not. Another individual of the same species would not necessarily be interested in his neighbor's nest.

S: Then why is he attacking them?

I: It's in the nature of the beast is what I'm trying to say. This is his territory and all intruders please stay out.

S: Except the cardinal.

I: Well, I'll ask you this - our cardinal doesn't eat the same thing, he doesn't live in the same area or the same kind of habitat. The cardinal is a smaller bird and also a year-round resident. He is not a migrant.

S: So you're saying that the...

I: Now, the question I'm posing is, is this any threat to the blackbird? Could he care less?

S: That's what I was going to say. He must realize that the cardinal doesn't want anything whereas it wouldn't do him any good because it's not usually where he lives.

I: In other words, it would appear as though he wasn't interfering with his life anyway so why bother him?

S: Was the cardinal still on the tree when the third redwing came?

I: Yes

S: I can't think of anything else.

I: Okay, you may have some other things to ask as we go on. This is quite likely. Now, one easy way to approach this is, let's say I give you

this problem where you're standing outside your back yard or school yard or something and you see this thing occur, this little seemingly insignificant incident. Investigate it, find some reasons for it, and draw some conclusions. How would you go about doing this? Principally, the question is how would you go about investigating this? What's the first thing you would do and then what's the next thing you would do?

S: I guess the first thing is to try to find out as much as you can about the two species of birds.

I: How would you do that? Go into as much detail as uou can.

S: I guess I would observe what each of the birds did and if I find them kind of unusual, I'd cover that particular or usually the broad things.

I: How would you go about finding something like this? Where would you go to read? What kind of a book would you look for? Where would you start?

S: Any place where they have books on birds. I would read up on a certain kind of bird, a redwing perhaps, and then compare it to a cardinal. You wouldn't compare it to the cardinal, would you?

I: Well, would you?

S: If I wanted to find out why the one redwing bird was attacking the other two, it wouldn't have anything to do with the cardinal. But if I wanted to know maybe why the cardinal...seems like I need more information. There isn't anything that you can think of why the other two would go near the redwing bird, or do different species like that go near one another or do they keep a distance?

I: You've seen more than one of a species in a tree or back lawn. So it's a common occurrence. For the moment, simplify it - don't think about the cardinal. Worry just about your redwings.

S: What did you say to simplify?

I: Well, just for the moment, forget about your cardinal. Work out a little bit on the redwings first.

S: I don't think that there is enough information given to try to solve this.

I: All right, let's see if there is. For example, why do you suppose two males would be fighting? Why not go out and gather chestnuts in May rather than stay around and fight?

S: The only thing that I can think of is jealousy.

I: In other words, you do agree that there must be a reason?

S: Yes.

I: Now, how would you go about finding what this reason or reasons are?

S: I guess that you would just have to read up on the redwing birds and find out the relationship with one another.

I: Let's further assume that you go to the library and there is no information.

S: Well then I would read up on the cardinal and see if I could find anything.

I: Say there is nothing on the cardinal. Say that nobody had previously worked on this.

S: I think that I would take my problem to somebody else and see what they thought. See if they could come up with anything.

I: Let's say that you are left totally to your own devices. How would you go about finding something about them?

S: I don't know.

I: What would happen if you just sat and looked at the birds for awhile?

S: Probably I would see something else that might be useful information. I can't see that somebody would go out and just see this and stop there.

I: Assume that this is only a small incident and things would happen. For example, what is an attack? Is it out and out killing each other?

S: Well, it couldn't be that because you say that one attacked the other bird so it flew away.

I: What happened before the other one flew away? How long did this go on? For what reason did it go on? We talked about territories, so he defends his territory, why? Is he defending it against this male, all males?

S: I think that you would have to observe them more than just that.

I: So what would you do? Say you think this is great and you want to observe more, how would you go about observing them?

S: Well, is there any place you could go to where they have these birds, not caged up.

I: You could go out to any marshy sand pit area here in Missouri and find redwing blackbirds anytime during the breeding season.

S: I think maybe that I would go to look for them both in the breeding season and out of it to see how they react with one another.

I: This is sort of a broad generalization. Okay, say that you are in a place where birds occur, now what exactly would you do? How would you go about

observing? Would you go once, six times, or would you go at regular intervals over a long period of time. What would you do?

S: If you were going to go and observe the redwing birds, you would try to see if this would ever occur again. But if you went several different times, you would be observing several different birds.

I: How could you tell individual birds apart?

S: How many redwing birds are there?

I: Thousands.

S: You know that you're not going to see the same one.

I: There is no way to identify a given bird?

S: If you said that they each had a territory, would that mean that that bird wouldn't let any others there? Would you know if he came back that it would be the same bird? Are you saying that no other bird will be on another bird's territory?

I: Not year after year.

S: Well, I guess you could keep going to that same place.

I: I think that you would find that these territories are rather small. You could sit and see two or three territories all in one spot.

S: That confused me, will you say that again?

I: You could sit in one spot like I'm sitting here and you could see one bird over here who has his territory while another bird has his territory here and another over here. The territories are not that large.

S: You would just watch the one territory and see if another redwing would come.

I: Do you think that you can watch just one territory and that that would be characteristic of all redwing blackbirds? Are we just concerned with just one individual here?

S: No, but if you had just these three territories that I could see, it wouldn't seem right if the birds were guarding their own territory that one would leave to go to another one, does it?

I: Oh well, sometimes birds are just ornery. Look at people, they are perfectly happy where they are but they go off and fight someplace. Same principle.

S: Couldn't I just be in this one spot and write down which territory I was observing and then just keep a record of just a certain male bird. Maybe

I could compare those three territories.

I: Do you think that it would be important to find out anything about exactly what they are doing in this territory that makes them want to defend it? Under what conditions do they defend their territory? What situations?

S: You would have to wait to see what reasons you could see.

I: Would you do this strictly by observation? What would you look for when you observed? You have to have some idea of what you are looking for.

S: Some of the likely reasons could be because he was guarding the nest there. Maybe he had a certain nest there for himself that he was guarding.

I: Let's introduce another variable into the situation. Let's bring our cardinal back into the picture. Obviously the cardinal represents the second species. How could you go about investigating the relationship of this redwing blackbird species to the cardinal species?

S: I don't think that it would be of any help to observe where the.... I don't know. The cardinal's territory - I don't think it would be any good to observe that because it is the redwing that you're concerned about, or could you? Do you think that it would be helpful to observe a cardinal in his territory and maybe try to figure out why he would leave? I mean, you couldn't really follow him to see where he would go, but there would be thousands of reasons why he would leave.

I: A territory can be something as small as this room or as large as a half acre.

S: What do you do if he just keeps on going - give up? Go look for another one to follow?

I: Possible. Did you ever think of marking your birds?

S: How are you supposed to get a hold of the bird?

I: Now how would you get a hold of a bird? Just using your ingenuity.

S: I don't know.

I: Well, they net birds. Essentially they are long nets....

S: Now, are you asking me what I could do?

I: This is the way you could go about catching a bird.

S: Do you think that I would have thought of that?

I: You might have thought that you could net a bird. But the technique isn't to important here as the thought that you might mark the bird.

Obviously, this must be done since there are so many birds flying around. What I'm getting at is that is one case you are investigating what we call intraspecific relations. Intra- within the species. One redwing blackbird as opposed to another redwing blackbird. Now the question is, are these kind of relations going to be exactly the same or different from the relationships inter species? In other words, between the redwing, the cardinal, the oriole, bluejay, or whatever other kind of bird you can think of.

S: Maybe try to get a hold of one of the redwing birds, and say one cardinal; and put the one redwing and the one cardinal and see what would happen and then put the second one in there with the cardinal and see what happens, and then maybe, for some reason the comparison between the two redwings and the cardinal are alike. Then you would know why one was attacking the other.

I: Rephrase that.

S: If you had two redwings and a cardinal and you put the one redwing with the cardinal and observed what they do, and then put the second redwing in with the cardinal and observe what they do. If anything went on, compare that and if it is alike, then you would know that was why the one redwing was attacking the other one because they had the same thing in mind. But you said that there wasn't any relationship between the redwing and the cardinal.

I: Not anything close. One eats seeds, one eats insects. It would be unusual if you would find them in the same tree together, in fact.

S: Well, if you knew that I don't think...

I: The other bird isn't competing...

S: If I didn't know that I'd try that, or maybe I would take the redwing with a different type of bird other than a cardinal and observe what happens there. Then I would put two redwings together with a different type of bird other than a cardinal and see what happens between the two redwing birds.

I: In other words, maybe nothing. With a bluejay they would have problems; maybe there would be a tremendous fight. Say that occurs, then what would you do?

S: I would have to find out as much as I could about the cardinal because I would know that it wasn't just the cardinal, it was different types or other breeds of birds.

I: Can you think of any reason for all those behaviors? I mean, can you think of how it would affect the individual or how it would affect his population, his species? In other words, say we have these two birds and one is defending his territory. Well, now what good does it do him,

really, to chase the other guy out? Or if the other guy gets in - what danger is it to him? That's one problem. The other thing is - we are considering a whole group of these birds which presumably live in the same vicinity, right? Now the fact that males living next to one another, fight each other, and they each have their own individual little spaces - how does this affect the whole population?

S: Of birds?

I: Yes, of all these birds of all of these species living together?

S: We don't know that. Maybe it was just the one bird.

I: Ah, now there's a fact. You could go out to find if that was just something weird about that one bird or if all birds did it.

S: I think what we would have to do is to take the first red male, well, you know what he does when another red male comes. Then take a different redwing bird up to the first one and put him with the male and the cardinal and see what happened. Then you would know if it was just the one red male or if it is always when they are together. *Or you could put a redwing* female and a redwing male with a cardinal and see if either one of them attack each other.

I: From this you can see what the problem is. Can you, in a succinct statement, state 1) what you would do and 2) what you would find out? What course of action you would follow in order to find out what facts you were searching?

S: I think that I would reconsider everything and if I were really going into this, I should have written down all the suggestions to try to bring the thing to an end. Then cross out what I don't think is necessary and skip the ones that I think are. I think that the more you think about it, the less important some of these things are but some of them become even more important. When I first looked at this, I didn't think of anything at all.

I: After you start thinking about it you can see different aspects of the problem. That's usually how such things develop. That's why we wanted to find out how you as an individual think about the problem.

Interview Number 5

Interviewer: We don't want to know what you know. We are interested, instead, in presenting you with a problem which you may never have thought about before and seeing how you attack this problem and what and how you would construct a way of finding out what explanation there might be for this problem and what it might mean. My function in being here is if you get

bogged down, I can help you, but principally I am your library, your laboratory, or whatever else you need. I supply you the facts. In this case we will assume that I am the expert on birds. You'll find on the piece of paper in front of you the problem. Let's say you are a biologist. You see this - what does it mean? Why does this happen?

Student: Is the cardinal related to the redwing bird in any way?

I: They are both perching, singing birds, but they are not closely related.

S: Is this the mating season? Are the males known to fight among the redwings?

I: They will fight among themselves.

S: During the mating season, do they do it especially among the redwings?

I: Yes, much more so than during the nonmating season.

S: What else is there to say?

I: I want to know what your hypothesis is for the reason and then how you would set about proving this.

S: I would say that the redwing birds fight during the mating season against each other. They don't regard the birds of the other species.

I: Just relax and think out loud.

S: Well, it seems to me that these birds are just going to fight with each other.

I: Why would they fight?

S: Superiority to win over the female bird.

I: What else? Keep going.

S: Do they fight for superiority?

I: In one respect. We have two males and they have established territories. If one male could come in and antagonize the first male and drive him off his territory, then the second male could take over this territory. So in that sense, it is for superiority.

S: But it doesn't have to do with mating at all?

I: Oh, yes.

S: You say in their territory - that's where they mate?

I: Yes.

S: In other words, they are fighting in order to mate?

I: Or to maintain. Redwing blackbirds are polygamists - they have several females and several nests on their territory at one time. There is also the feeding aspect. They feed on this territory.

S: This could be part of the struggle to survive.

I: You have advanced several ideas here which are all good and valid. You don't know that they are valid. How would you experimentally set up an experiment to prove this?

S: Are you giving me facts or possibilities?

I: They were just moment possibilities - the feeding, etc. Now if these seem logical, then you say, "Now can I prove it?"

S: Then you could set up some sort of an experiment where you could borrow an amount of land and put in twenty female redwings and have one male redwing. Then you observe his eating habits and his mating. Then I guess you could put in another one, but I don't see what it would prove.

I: How about the question, do redwing males ever fight with females? Do they just with males? This might change the nature of the fighting or the reason for it. It is little things like this that you have to consider. What about young males? We know breeding males fight, but do young males?

S: Those are good questions. Sounds like I'm just asking you what you say but that's what I'm doing. Okay, do the young males fight?

I: Yes.

S: Among the older males? Do females ever fight among the males?

I: Yes, they do. You will find that females that are in the same territory with the same male as a mate will quite often fight among themselves early in the breeding season. When they lay their eggs they don't fight so much. The territories are restricted to a real small area right around the nest.

S: Do the females fight among the females?

I: That's what I meant.

S: Do the females fight among the males?

I: Quite often before the female is ready to mate, the male will chase the female. And if she is not ready to mate she won't so much fight with the male, but the male will actually fly after her, grab her rump feathers, pull her down to the ground, and get violent about the whole matter. So there is this fighting between the sexes.

S: But it isn't to drive them out, actually as to convince them.

I: What do you think this might be for as far as the females are concerned?

S: More or less control of some sort.

I: Yes, it is what you would call establishing the pair bond. They have to go through this business; it's a ritual the male goes through with every female. And if they don't go through it, the two of them won't mate.

S: When the male comes in he is just trying to gain territory, right?

I: Could we assume that he is just chasing a bug?

S: But the other one doesn't know this.

I: Maybe, he is just ornery. Maybe he is just trying to cause trouble. A young male - you could assume this is what he is doing.

S: The cardinal isn't doing anything like that.

I: Well, he may be feeding in the same area, but perhaps...

S: Can the cardinal breed with the female redwing?

I: It would be breeding season for both of them, but the female redwing simply doesn't respond to a male cardinal. He would have more of a fight on his hands than he would know what to do about. And then the young wouldn't live. Keep in mind that the cardinal and the redwings eat two different kinds of food, although the food may be contained in the same type area. What does it occur to you that this male aggressive behavior is accomplishing toward the other male and for the whole population of redwings in the area?

S: Wouldn't it keep the population stable?

I: Beautiful - yes. If you wanted to actually get some statistics on the population density as it's controlled by territories that birds maintain in numbers, etc., how could you go out and do this? How would you go about finding this information?

S: Doing the experiment yourself?

I: Yes, to get some information on this. Assume that the first thing that you did was to go to the library and checked this out, and maybe you found some information for other species, but not for this one.

S: You could go about this generally the same procedure that they went through .

I: Yes, I think that it would be a good place to start.

S: I couldn't really say what the procedure would be. Do you want me to say...

I: Just what occurs to you might be a good idea.

S: Well, you couldn't very well go out and count them. First off, make each thing into a region. How are you going to determine the region?

I: What about the idea of taking a few acres and cutting it up into squares and count the number of birds in ten squares figuring that's average?

S: Okay, but you would have to pick a place where there were redwings.

I: How would you find out where the redwings are?

S: Observe, I guess.

I: Or you go to a field guide which gives bird distributions, where you'll find them, etc.

S: How did he find it all out?

I: The man that actually worked this out was a bird watcher and had a field guide. This is from thousands of bird watchers all over the country.

S: So you couldn't do it by yourself though.

I: You always rely on what goes before you which points up the importance of libraries.

S: You could take into consideration where to go and let the field guide tell you.

I: It will just tell you where you can find your birds, then you must find the population.

S: Section it out and set up where you think their territory would be or the average number of birds.

I: What about distribution in the population? Do you want to know how many are males and how many are females?

S: You would take into consideration the land itself and what it's like. If it is all the same then it would be more or less controlled. If you had different land in each part, you might find some other food. Like if you were near a lake and there was some food or plant that grows there you could see if the younger go over to this place. If they eat this food and more come, you would know that was what they want. Then you could make a comparison with the land and the number, the size, the age, the sex.

I: Do you suppose that you would be interested in all the relationships of the other birds in the area?

S: They could be related to the food. They eat the same food - the same berry or something. If there were an overabundance of blackbirds or something you might not find as many redwings because the food supply was shorter.

I: Great. Do you have a little more insight into the problem than you did when you first looked at it?

S: Yes.

I: Okay, then if you do, go back for a minute and sort of recapitulate briefly what you think the major points of the problem are and what you would do. In other words, you've had a chance to sort of think out loud now so organize your thoughts briefly. Just come to some conclusions.

S: It could be nature's way of controlling the population to make sure that everyone survives and is able to. There is the factor of survival.

I: So you would solve this by what, principally observation?

S: Yes, observation. I think it is maybe the species or whatever the group of birds that exist, their way of living, and anything that is going to hinder their way of living is what they're going to fight. That is always their specific purpose.

I: Survival of the individual, the population, and the species.

S: I guess so. That's a good way to say it.

Interview Number 6

Interviewer: Have you been told anything about what you are here for?

Student: I don't understand what they were trying to tell me. They are going to give you a problem that you are to think out or something.

I: Perhaps I can clear this up a little more. Let us assume that you walked outside and you saw in a tree just what is outlined here. And I said, "Okay, fine. Now why don't you write a little term paper on what you just saw? Describe the problem. Form some idea in your own mind of what might be going on - what the significance of this might be and then, prove it somehow. Prove it by your own observations or whatever. When you're all done with this, come to some conclusions. That is, were your original thoughts correct about what was going on." So this is essentially what we want you to go through here. So you ask any questions that you might have.

S: I have an idea why this is going on because we had birds in seventh grade. Does this kind of bird pick out a tree and then sort of make a

nest in it? It wants this tree for itself, doesn't it?

I: Yes, we call that territory. Male birds, during the breeding season, will establish territories. That is an area of land, or a tree - it varies from a very small area to maybe a thirty-five square mile area in some species. But they defend. This is mine. They will fight anything or anybody.

S: They make it their own private property.

I: Exactly. Just think out loud. Don't try to force yourself into conclusions before you're ready.

S: Well, this bird is sitting in a tree and it is the breeding season of the year. These birds are trying to get in his territory and he wants it for himself. This cardinal comes, and it isn't the same kind of a bird. Maybe the bird is going to get, like his wife, and the cardinal wouldn't want to have the same kind of a bird but this other kind of bird would.

I: Maybe you need to ask some questions about these two different kinds of birds. About their habits.

S: This redwing goes out and finds a mate and brings it back to its territory. But then this cardinal comes in. Would he want to take the mate from the redwing?

I: No.

S: So that's why the bird doesn't try to run him out?

I: This is true, but let's interject another factor in this. Or a couple more. Besides mating in territories, they also feed in their territories. Does this suggest anything to you?

S: It could be that the birds don't eat the same kind of food.

I: That's exactly the case between the cardinals and redwings.

S: What do cardinals eat?

I: They are seed eaters. Redwings eat insects.

S: Like if the territory...no, it can't be because cardinals already live in there.

I: He may not be already living there.

S: Well, he wants to. The territory has the food for both and since the redwing knows that the cardinal wouldn't eat his food, he doesn't chase him away.

I: A succinct way of saying this is that there isn't any competition between these two birds. They're not really competing for anything.

S: And there is food for both of them. Each have their own set of food and there isn't any competition.

I: Now, why don't you think about the other redwing?

S: The first redwing sitting in the tree has already got this territory so this other one sees it and decides that it has the right kind of food and he wants to make it his own, but the other bird chases him out.

I: You're doing fine. Go on.

S: If another redwing came in, he would chase it out too.

I: What else might these other birds be doing that involved competition with one another besides eating? What other things do they have to do to survive?

S: I don't know.

I: They have to reproduce.

S: Then the mate...well, he may be trying to take his mate away from him.

I: That's right.

S: The redwings are in competition for their necessities, but the cardinal doesn't have anything to do with this so he gets to stay.

I: Where do you want to go from here? You have a very good hypothesis there. I would go along with what you say, but you don't know that what you've said is right. So what I want to know is, given this working hypothesis that that is what is going on, how would you set out to prove it? Start at the very beginning.

S: You would get your spot picked out - anywhere that had the right kind of food for both of these birds in the same place. You stick the redwing in a tree, and then you could let him make it his own.

I: Wouldn't it be better to go someplace where both of them occur? Where both are already there? It would be easier on you.

S: It would be a lot better if you could find a place.

I: How would you go about finding a place like this?

S: You would have to know where these birds usually live.

I: Do you know where you could find that out?

S: You could read on it and do research.

I: That's right.

S: Do research on where they go in the summer because they would go where the food was. You would also have to find a place that had food for the cardinals too. You get this one redwing, and you watch and you figure out what its territory is.

I: Okay, let me interrupt again. How much time and when would you do it? How would you go about watching these?

S: You would have to go there pretty constantly because if you were there for just a couple of hours, you couldn't even tell. You would have to do it for awhile in order to be able to tell just what area this bird has picked out for himself.

I: Do you think just by watching you could decide where the bird's territory is?

S: You would have to mark them some way so that you could tell them apart since they all look the same.

I: Do you know how you would mark them?

S: You can put a band on their leg or something like that. And you should catch a bunch of birds and watch them - you would have to band them all. If you catch a bird that had a band which belonged in another territory, you could tell where the bird goes.

I: With most of these small birds, you could sit in one spot and see the territories.

S: Just by watching them?

I: Yes, because they are small areas. They will go outside their territory, but the part that they fight over is a pretty small area. So this increases possibilities of observation. You can sit and watch this all going on. I might also add, in the case of the redwing, they take more than one mate. They are polygamists. That might give you something to think about too.

S: You just sit there and watch them to find what their territory is. There are cardinals flying around too, and you've been watching them fight off the redwings, but you see that they just let the cardinal stay there.

I: What about other birds? We've determined that cardinals and redwings don't eat the same food. What about another bird that eats the same kind of food as a redwing?

S: They would probably fight him off too, because they would see that he is invading their territory.

I: How would you make an observation about something like this?

S: You could put this third type of bird in there and see if it will go for the food. Whatever territory it goes to you would watch to see if the redwing fights him off. I guess he probably would because he was invading his territory.

I: You could easily enough determine this just by using your eyes, couldn't you? Do you think there would be anything worthwhile in investigating how they actually fought?

S: I don't see what that has to do with the problem.

I: Ask me some questions. I keep suggesting another line.

S: If the problem is just dealing with these two types of birds, what difference does it make how they fight?

I: Well, it makes some difference to the birds because every species of birds has a very ritualized style of movements that it goes through. The birds don't really fight - they don't come to blows. They come around bobbing their head, lowering their wings, and going through all sorts of absurd movements. Suddenly one seems to be declared the winner. That's the whole business of the behavior. They don't hit them very hard. What the redwing blackbird does, the cardinal will not do. He will do something different. And apparently, one has no effect on the other.

S: How could one come out the winner and one come out the loser?

I: That is something we don't understand. If you could answer that, you would be famous. They are a little more civilized about this than people are. The blood doesn't flow. Now that I've told you there are stylized movements, is this something that you ought to look for?

S: If they don't really fight, just fly around...

I: What I was getting at is do you think that it would be worthwhile to describe the kinds of motions that the redwing went through? Also to describe the motions that the cardinal went through, showing that they bear no relationship to one another? Or maybe, all redwings go through exactly the same kind of postures. See what I mean? That is the kind of thing that may prove to be significant.

S: Maybe, it could show you the birds really don't have anything in common if they don't do anything alike. The bird wouldn't even bother me at all. So just let him stay.

I: One might compare it to your parents who have certain reactions and feelings toward you. Consequently when they see you they will say, "There is my daughter," and will say all of the appropriate things.

If you just changed appearance overnight and walked in one day and didn't look like yourself, it wouldn't bring the same kind of feelings to their mind at all, would it? Okay, see what I mean with the birds? Now, you could explain to your parents, "Now look mom, the witch turned me into something else." Obviously, the birds can't explain it to one another.

S: So they would see that they didn't have anything in common. The redwing would like the cardinal stay because he wasn't going to bother him - he wasn't anything to him. But if another redwing came in, I guess he could tell that he was another one of the same species that would try to eat his food or take his mates or something.

I: He wouldn't be a threat in other words. Now you can describe this; you can observe this and put it down on paper that I have observed this and that. This is what the bird does in his territory, etc. We have a population of birds - let's say we have fifty redwing blackbirds, okay? Each bird has his own territory. We know a relationship is here - here is the first bird, there is the second bird. This keeps these two birds apart.

S: Do the territories ever intersect?

I: No. It isn't a good territory if it does. They should be exclusive of one another. Can you see any relationship of this territoriality density? What conditions would be like if this did not exist?

S: The territories would keep the population in one place pretty well the same. If there weren't this, there could be twice as many birds, or fewer birds.

I: Each male has approximately the same size territory.

S: Then you could tell about how many birds were in that one area. It would be spread pretty even.

I: In other words, you are saying that by scouting the individual bird, you can begin to tell something about what a group of birds in a territory can be like. This is fine. What might this mean? What significance is this to the population? They are all well-fed. They all have nests. They are reproducing. What is significant about this for the birds?

S: The type of bird would probably not die out very easily.

I: So this tells you something, doesn't it? If we look at this thing as a ladder. We start with the individual bird, here, from the bottom. So goes his life. There's the population and as it is successful so is the species.

S: When a bird and the bird's little babies grow up, do they stay in the same area?

I: Well, it depends if we are talking about migrant, which this is, or resident birds like the cardinal. The cardinal is here all year round. He doesn't go anywhere. But with the redwing blackbird, after the young are fledged, the female and the young females and the young take off. They go completely apart from the males and they'll stay this way almost the whole of the year until breeding season comes around again.

S: Do the same male and the same female mate again?

I: Frequently, if they are still there and get together. The males will quite frequently come back to the exact same territory they were in the year before and the females will come back to the same spot and they will breed with the same male, you see.

S: Do the males ever seek out the same female?

I: To say that they actually seek out an individual, I couldn't answer you, and I don't think anybody knows. It would be hard to know what's chance and what's actually attributable to the birds themselves. We can band them, and say this male and this female got together again.

S: If you banded them before the female left the nest and you saw that she flew away and moved somewhere else, couldn't you tell? If the male stayed around - do they?

I: No. They leave to wander. They all come back at breeding season.

S: It would be pretty hard to tell.

I: It would require some very exact and delicate behavior experiments to see how much birds respond to actual individuals. That we don't know. Do individual birds distinguish between one another - this female is different from this one? And somebody will probably do this some day, but this is a little bit finer than we work with them to this date. You've come a long way from our tree. You're talking about the success of the species which is very much a part of territoriality. You might want to consider such things as what about territoriality in females? What about aggressive behavior between males and females? Do males ever attack females and why might they? Do males ever restrict their aggressive behavior strictly to other males?

S: You said that males of the same species had lots of wives or mates. Unless they got sick and tired of them, I don't see why they would attack them.

I: If you had one mate bird, and you had several females - how do you think those females would get along?

S: They probably all would be fighting.

I: Do you think that the male bird could take this very long? Especially when he was trying to mate with this one over there and number one comes over and bugs number two? That might cause some problems.

S: Yes, he would probably...I don't think he would fight to run her off like he would a male. He would fight with her to tell her to mind her own business.

I: Do you think that you could design a very simple little experiment to see how this would work? I'm the laboratory. I'll give you the birds. Here are six females; here are all of the birds; here are the cages and everything you need. What would do to prove this?

S: You would have to get some birds who are already mated. Put them together so they would mate. How many females do they usually get?

I: I don't know. Let's say three or four.

S: Stick four females with a male. You would have to do this a couple of times to see if they work out the same way each time. You put the male in there and you see that he is having a relationship with one bird, and the other comes over and he runs her off. You would already know how the two males fight - they probably do a lot more of their fancy stuff than he would do with the female because he doesn't really want to run her off. You'd have to watch him to see how the male reacts, if he really wants to fight with her or just. . .

I: Putting her in her place. Let me give you another situation. Something that you can observe in redwing blackbirds is that occasionally here will go a female flying over the ground very erratically like a moth flies, back and forth, and here comes the male after her. He will actually go up and grab her by the rump feathers and pull her down on the ground. Now this is before mating takes place. Can you think of any explanation for this? It's obviously aggressive behavior on the male's part.

S: That would kind of be like dating.

I: You've go the idea.

S: He goes after this one bird.

I: Again, how would you go about proving this little segment?

S: You could put a bunch of females in a cage with the male that have never seen each other before. Watch them and if the bird started doing that to any of the females you would know that he likes her.

I: Did you consider controlling it by putting in two that he has already mated with?

S: That's a good idea because he would know that he already likes the first two birds that he has already mated with. You could tell that he wouldn't be lonesome with the one and just do it because he needed one. I don't know if they are like humans or not.

I: We will assume they are more so, since they can't think.

S: That way, well, he has these other two, and if he likes this third one and he starts pulling her down, you could tell that he likes her too.

I: Now let's go further back to the beginning. What kind of behavior would you say that this whole problem deals with here? Would you call this happy behavior? What kind?

S: Well, he is mad at the other redwings because they are trying to invade his territory. They are trying to get at his females or at his food. The cardinal has no significance at all so he lets the cardinal stay.

I: The core of this problem is what we have talked about and all of the things that you might be able to do. It's investigating aggressive behavior, is it not?

S: Yes.

I: I mean, all of this involves aggressive behavior in one way or another.

S: Because one redwing is being aggressive towards the others in trying to run them out.

I: In other words, this suggests the idea of aggressive behavior and then you can go on to find aggressive behavior is involved in other aspects than just the males fighting one another, all right?

S: Yes.

I: See what I mean? This is just a corner of the problem, really. But this is what gets you started on it.

S: He is aggressive towards the females and towards these redwings who are trying to invade his territory. He would also be aggressive toward the cardinal, but then I doubt that since they don't have anything in common. He is aggressive toward the female because he is trying to either put her in her place or mate with her. And the redwings he is trying to run out because they are getting in his way.

I: You've got quite a bit more insight in this problem, right? You've sort of talked it out and you see all sorts of aspects of it that weren't obvious to you when you first read it. Now, since you have thought about this a little bit, go clear back to the beginning when I suggested that you were going to do a little research paper. Now in very simple, straightforward terms tell me what your steps would be in starting to work on this paper. What you would do first and in a general way how you would go about investigating and then what conclusions you might come up with.

S: First of all I'd watch these redwings to see how they acted and I'd see how they act towards males and towards females. I'd figure out that they were trying to run the males off they were just keeping the females in

their place. I'd do all of these experiments to see and get some facts. These would be necessary to prove all the little thoughts that you had. You'd have to study them and the cardinals and if you put any other birds in there, you would have to study them. Then stick all of these facts together and if any of them bear relationship to one another, then you go on and investigate more specifically to...because you have more specific facts.

I: You're working from generalities to smaller specifics. Right?

S: You come up with just a few real specific facts. They have one point that they are talking about and they prove this point and show what it has to do with the rest of them. Then you work these into a reason why the birds act like that.

I: You have to start out with an idea to work from, obviously, and then you go through all of these experiments and say, "All right, how does this compare with my original idea? Does it or does it not prove it?" One thing that you neglected, and you might keep in mind one of these days - the easiest way is to go see what other people do first. Get an idea first of how they went about doing these things. Then you can start out knowing John Doe went out and did it just this way. He had one square acre and he divided into fourths or whatever, and he watched the birds at such and such time of day. You could benefit from all of his experience. Then you sort of forget about that and go ahead with your own work, and then at the end you compare your data with what everybody else got.

S: You would do all that, and then what if you came up with an idea completely different from what somebody else got? Would you see how he got some of his ideas?

I: Sure. That's one thing you want to think about. I've got different results, and the reason may have been A,B,C, and there always should be some kind of a reason. Some may be more acceptable than others. If you had a different species of birds, then you would expect slightly different results. Maybe he was sloppy, maybe he misidentified his birds or something as simple as that. There are always things that people quite often forget.

Interview Number 7

Interviewer: The whole object of this is we don't want to know facts. We are not here to test you on what you know. What I am here to find out is how your thinking processes work. Given a problem, what do you do? Now as far as the facts go, obviously, you can't think on our problem without knowing something about it. That's what I'm here for. You ask me for the facts. Let's say I ask you to

do a little research project. I'll give you the project and now you find out what you can do about this. First, the thing you are going to do is given the problem, your mind will have some kind of an answer. Some hypothesis that you will work on. But I said research, so I want you to prove your hypothesis to me. This means that you will have to design an experiment. You have to ask questions and then find answers. And then at the end of all of this you'll have to put all of your information together to come up with a conclusion. This will either agree with your hypothesis or it won't agree, or maybe, half and half. Okay? Do you have any questions about the start of the procedure, here?

Student: I'm just supposed to give you like a hypothesis first?

I: First of all, what is the problem as you see it?

S: A redwing male will attack another redwing male, but won't attack a bird of another species.

I: Fine.

S: Are the cardinals and the redwing bird the same color?

I: No. The cardinal, of course, is bright red, the male anyway. The redwing blackbird is all black except for some bright red on the shoulders. They have a completely different appearance than the cardinal and they are slightly larger.

S: Is the cardinal like the female redwing?

I: No, they are differently shaped. Although the female redwing and the female cardinal are sort of a dull brown, they're not as characteristically marked as the males are. If you had both of them side by side, you would have no difficulty telling that they were two different birds.

S: I think it might have something to do with they might attack a color. The redwing might have something against its own species, like the male. Like it might want to attack in mating, or something. They might think that that bird is going to attack its female.

I: So this is your hypothesis. Would you like to restate it in a little more general way? There is competition between two males of the same species. That's our hypothesis. We need to find out something about what now? We need to know why there is competition. Right?

S: The season might have something to do with it. Spring. Like some dogs are different in different seasons. Spring might have something to do with it.

I: Do you want to ask me questions? If you want specific answers, ask me.

S: Well, does the season have anything to do with it?

I: Right, because they have a certain breeding season that lasts two or three months. Males are aggressive all year long, but during the spring they are very aggressive. They establish territories; they defend them.

S: Is this the same for all birds?

I: Yes, almost all birds.

S: It seems that it didn't pay any attention to the cardinal - so that means that different species don't interbreed?

I: No, they don't.

S: You could make an experiment to see if that happended just in that species, or something. You could use more than one species of birds to compare the behavior. You would probably use like five different pairs of birds because you could feel that you could rely on this.

I: That's very good.

S: The location of this bird...I don't know if that would make any difference. Like the tree would probably be where the nest is and if you put the two birds in another tree...but of course, they stay by their nests don't they?

I: The females do.

S: The males don't?

I: The males have a territory which is an area of ground that they will defend. But of course, on this territory they nest and they have several mates. They also get their food. Everything goes on right in this area. It is literally their home ground.

S: There's no specified area?

I: Oh yes.

S: I mean, is there a certain number of trees or a certain area?

I: This is hard to tell. A territory has to be large enough for the birds to get all their food from. It has to be large enough for the females to happily nest. Now how much area this takes...for example, if they have to have an area with a tree, then that area must have at least one tree, right? In the case of the redwing, as a matter of fact, they don't need a tree. They nest in marshy, swampy areas. But, nonetheless, all the qualifications that they need to survive must be in that area.

S: The reason that he might have attacked is that the other redwing was getting food out of his area. And he would think that my bird needs the food. But

it said he never came back. After attack, will they immediately fly then?...so that means they are afraid of each other?

I: Do you want to phrase a question about that?

S: Are birds of the same species afraid of each other, the males?

I: A male bird, if he goes in another bird's territory, if he is chased at all, will usually stay out. In other words, this is sort of an honor rule. What's yours is your own and what is mine, is mine. And for one reason or another he mistakenly gets into the territory, or maybe he aggressively goes in there, with the idea that he is going to take this territory away from this other bird. If the bird on this territory goes through the right motions - these very stylized motions that birds go through which we call aggressive behavior, then chances are the second bird will say, "Okay, you win, I'll go home." Just suppose that he doesn't do the right motions; then the second bird has a better chance of moving in.

S: Then a third bird comes and he is chased away again by the first one, like he will defend his territory no matter how many come in. Do male birds fly in flocks?

I: When they migrate, there is one whole flock. Occasionally they will mob if there is an outside animal that is completely different. For example, a redwing blackbird flock might mob a sheep or a horse that might come into their area. Instead of just one going after him, he might get two or three. They might light on the horse's rump and peck at him. Or they might fly to the sheep's head, or something like this. But, this obviously is where this animal represents a danger to all of these birds. In other words, these birds think so. It might destroy their habitat and they don't want any part of it. Normally, a bunch of birds will not gang up on a bunch of birds of another species. This is strictly a one-to-one deal.

S: I was just thinking how birds come into our yard. A lot of them come at once.

I: Oh yes, they're gregarious.

S: But I don't know if they're males or females or whatever they are. Like if they came...like say three came, could he still defend against these three? Would he be afraid?

I: I think that, for example, you get a bunch of starlings landing in your yard, it's a matter of it not being the breeding season. This territoriality is strongest around the nest at breeding season.

S: Also, would this take place only on a tree? Would he only protect on a tree? Like a lot of times they sit on telephone wires. If it is in the area - would it still be the same?

I: It would just be wherever his territory is...within his territory.

S: But it's not just to this one tree.

I: No, if it's a quarter of an acre in the middle of the desert, that's what he is going to protect. Can you begin to see what sort of consequences this might have? This business of aggressive behavior to defend the territory. What kind of emphasis might this have for the bird itself? What is the significance to him?

S: He is protecting it and if he didn't, don't they steal the eggs? Couldn't they attack the female and then the eggs might not hatch?

I: Basically, what we're saying, is that by protecting the females and the eggs, he is assuring that the birds are reproducing. So that is one aspect. What is something else that you can think of?

S: Do you mean, if the bird doesn't protect it, what would happen? Are these helpful to the farmer? Or to man in some special way? If the birds attack each other, can birds kill each other?

I: They can, but they very seldom ever do.

S: Can they injure each other in ways?

I: They are capable of it but that is something they don't do because they go through this business of stylized movements and at a certain point it is all over with. Whoever did these movements the best was the winner but no blood is ever shed, which has something to be said for them.

S: It's kind of like who can do it the best without really hurting each other. Well, then you could say that the male could't really become extinct. Do all males attack because of the area?

I: Well, if one male for some reason or another doesn't react like all of the other birds, what's going to happen to him? It would seem obvious that he would be in the losers' territory. He won't reproduce. He'll be sort of an outcast. He won't contribute anything to the whole group. Can you see then from this how this aggressive behavior and territoriality affects the individual? He either does what he is supposed to do to survive or he loses. Now carry this one step further. The birds, of course, live together in a population or community. Obviously, the population is made up of each individual bird's attributes. Take one out, you change the nature of the population some way. It may be minute - but it's changed. So, as I was showing somebody else, we have a bird who is sitting here in his ground. He sits here in his ground because next to him is one who sits here in his, and so on and so forth. Now, if all of these birds suddenly gave up this idea of territoriality, can you imagine what massive confusion there would be in the whole population?

S: They just kind of would be wild.

I: There wouldn't be any organization, would there?

S: There wouldn't be any territories. No organization whatsoever. Just

mass confusion, as you said. Would the birds just fly around all of the time?

I: We would have the problem...would the females know where to go? Where would different females nest with particular males that they are interested in? How would they distribute the food? You don't want them hunting in exactly the same spot. So you see the consequences of our territoriality and aggressive behavior - not only for one bird, but for a group of birds?

S: Really, it looks like it would harm the females a lot more than it would the males because they wouldn't know where to have their nest. But do the females build the nest?

I: The females are territorial up to a point within the male's territory.

S: Well, I thought that the male kind of helped build the nest.

I: In this species, they don't. In most species they do. He stands by and watches in this species.

S: Does the male pick it out, or does the female pick out the nesting place?

I: Probably, the female. Now you have a pretty good hypothesis, right? You've got an idea, now, of what's going on. Let's go back to the beginning and say, "What would I do? How would I set out to show some of these things?" In other words, how would you set out to do this?

S: Probably by experiments like when we set out with different pairs. You kind of get a general hypothesis on that. You would say if that proved that...

I: Well, how would you find out what was normal for the birds? What they usually do?

S: Watch them. Observation. Wouldn't this be on some wildlife reservation or something?

I: Yes.

S: I guess you go anyplace where the birds occur. You'd have to find the redwing. But don't you kind of scare the birds?

I: Birds are remarkable. For example, if you go to talk around birds, movement will alarm them, but they can't hear what you're saying because they can't hear that frequency. So you could talk or yell or do whatever you want. You could simply go out and sit very still. It's remarkable how tolerant they are.

S: Then you could take films or something. But that wouldn't scare them. Like you get more than one nest in one territory or more than one pair of mates, and you could kind of get a general pattern there.

I: It would be interesting to be able to identify individual birds, too.

S: You could see when other birds come like the cardinal.

I: Would you do this one day or... .

S: Probably be about...you couldn't do it one day, because they are different on other days. From a week to two weeks or a month earlier. You'd have to do it in every season too.

I: Probably through the whole breeding season.

S: Yes, during the spring. And they are different during the summer. When do they migrate south?

I: August, September.

S: Well, like that, and when they are coming back. You'd kind of have to do it often over a long, long range.

I: Do you think that it might be interesting to do it over more than one year?

S: Yes, because there might be the effects and the climate.

I: What do you suppose happens to the first-year birds? The first-year birds won't breed, you see. They're there, but they don't breed. They're not physiologically ready yet. Do you suppose they are subject to attacks? Could you just forget about them, or would they be important?

S: They kind of would, because to watch them develop and how they started out, and then - I bet this aggressiveness comes gradually. Like when they're developing and then...I don't know how old they have to be. Kind of like he is immature or something like that. I guess that would be an observation too.

I: In the first place, we will assume that you can tell the sexes apart. What would you do about telling the structure of the population as far as the first-year birds?

S: Well, aren't they smaller?

I: Not appreciably, no. The difference is internal. First, you'd have your observations. You could tell if a bird was on his territory and you might have an idea that this one was coming in and bugging the first one. You could tell a small, young bird because he wouldn't have a mate, but how could you prove this?

S: That's a good question - you want to know how to prove that it is a first-year bird?

I: Yes. You would look at it after you had captured it and this would give you an idea. Then you might be able to identify them externally somehow once you had one that you knew was a first-year bird.

S: But you would have to look at it. Can you capture birds like that? Without killing them?

I: Oh, yes.

S: Wouldn't it be better to let it live?

I: Yes, you could capture them with a net like a very delicate volley ball net made out of fine thread. You put these up so the bird will fly into them and get caught. You take the bird out and band it or examine it or whatever, then let it loose. It doesn't hurt the bird at all as long as you handle it carefully.

S: Well, really, that might be a better idea, because then you could watch it, like you say we band a leg or something like that. You could watch that bird and see what it did and then if it was still banded as it still kept growing and developing, you could tell where it was going and how it bred.

I: And obviously, there is a great deal that this little problem could lead you into. We talked about aggression - the actual act of fighting. I mentioned that there were stylized movements that they went through in fighting. Do you think these movements might be a part of your observation? What these birds do?

S: I think it would because it depends - like they did one thing...like they had one certain movement or sounds that might mean they were going to attack or want to have food there or something like that. If you hear these same sounds or saw the same movement or group of movements more than once, you'd know that this was kind of a pattern.

I: You might be able to pin-point and say that means such and such.

S: Aggression or. . .

I: And you could watch the birds and know exactly what was going on. Now specifically, how would you go about finding out about the movements? Say you want to describe it in your paper. You feel that it is quite important.

S: Probably it would be something like the wings or the head.

I: You're right. But how would you record this so that you could interpret it? You could observe it but all of this happens very fast.

S: I was thinking that the way you would observe it would be like filming it. Because then you could slow it down when you're watching it. You could watch each movement individually and then you might detect something.

I: Do you think that this would be important to do with several birds?

S: I think it would. What do you mean--different species or just the redwing?

I: Whatever you think important.

S: Well, you would have to do it with more than one bird of any kind. And then if you wanted to you could compare different species...if this were normal in all species. Like you could do the cardinal, and I'm sure that the cardinal is probably different from the redwing because the redwing bird didn't react to the cardinal. So you might do something there too and you would just be leading on to different things in your observations.

I: I'll say you have compared a goodly number of each species, so you knew what each species' movements were, and you found that blackbirds had movements that were all quite similar. In other words, they went through a series of where they would break out into a one, two, three, four, five. Up to four all the movements were the same, but in five there were little things that were different. But these were all quite similar from the blackbird in general to the robin and the cardinal. What would this mean to you?

S: There is more than one kind of blackbird isn't there?

I: Yes. There are several species in a genus. Genus is a higher group.

S: You could say that blackbirds are alike except for different movements. Do they attack each other like you said the yellowheaded blackbird, or something like that?

I: They quite likely can if they occur in the same spot at the same time.

S: Well, like they might attack...they're still the same genus but they're not the same species. But the cardinals are in a different family all together, and so these blackbirds are related more than they are to the cardinal.

I: So you think that that might account for the similarities in movements?

S: Yes, because they are in the same genus and the cardinals and the robins are in a different family. You could just kind of relate it.

I: So in other words, it might have something to do with their evolutionary relationships?

S: Yes, how they develop. Like how one redwing and a yellowhead might be different. There might be something in the color or something.

I: Okay, that's a good observation too. Now, this is a hypothesis. Let's say that you did this on all of these birds around here in North America.

Then let's say you did some observation on birds in Asia clear on the other side of the earth. They had similar habitats, acted the same way, even looked alike. Would you assume then that these two birds were related?

S: No, just like you said it would be because of their similar habitats. And then also it might have something to do with the influence of a tree or same surroundings, etc.

I: In other words, it wouldn't imply a close relationship. Another question, what would you do if, for example, the cardinal didn't seem to disturb the blackbird? Have any idea why it might not?

S: It might be the color.

I: Let me bring in one more fact. Cardinals eat seeds and grains. Blackbirds eats insects.

S: He did attack his own species because maybe they were eating his own food. The cardinals eat seeds, and the redwings instinctively know that they are not going to attack their food.

I: In other words, there is no competition.

S: Yes, no competition between these two birds of the two species. The feeding habits of the redwing blackbird affect its aggressiveness during the mating season. Then you would have to try to prove this. You would compare two species like the cardinals to the robins and the redwing blackbirds. When you compare, like five, you would do it within the species too. Like with five pairs of the redwing blackbirds...and those with a different habitat than another five and see if it is still similar there. You would also make observations....You would have to observe them for a period of two years. But you couldn't make this conclusion within a week. During all the different seasons, like the mating season and during the summer too. And also, you would have to do it in different areas. You would go to different countries and observe.

I: You mean different areas where this bird occurs?

S: Yes, to see if they were similar in all areas. Also, you might...like somebody else says...after you make your conclusion, they say well this place where they live might make a lot of difference. That can change or make a bird....The habitat of a bird might make them act differently.

I: In other words, the bird adapts to its environment.

S: Yes, and this might make a difference. This bird would have to be observed in different areas.

I: Could you make a general statement of what you think the significance of the aggressive behavior is to the bird and to the population of the species? Just in general.

S: The female might be hurt more through the aggressiveness of the male because if they don't defend their own territory and they let other birds come in, the female will lose its...it wouldn't know who their male was or....

I: In other words, you are saying that the reproductiveness of the population would be in danger? Do you see biologically the importance of this problem? In other words, is it more important to you now than when you came into the room?

S: Yes, I didn't know a thing birds when I came into the room.

Chapter IV.

Introduction of the Student to the Task and Problem Situation

The following printed instruction to the problem was presented to each student at the beginning of each interview followed by a printed statement of the problem situation.

> The task you are being asked to perform is to read over an account of events observed by a team of researchers from medical and anthropological areas, then to plan an investigation into a possible cause of a puzzling and unexplained event.
>
> You can ask me any question which will help you perform this task. I will try to tell you what is known by biologists and other researchers in related fields, but I will not tell you how to use this information unless you specifically ask me to. In other words, I am not here to teach you, but to learn how you would go about planning and thinking about results of an investigation of a puzzling event.
>
> We would like to tape-record our interview; is that agreeable to you? Your name will not be used in any report made of this interview, nor will this be in any way a test on which you will be graded.
>
> After you read over the statement of the observed events below, you can begin to tell how you would investigate the unexplained event, or you can ask me for any information you would want to have at any point.

Men and women in a small village in Central America were observed smoking and drinking in a ritual ceremony, seated in a circle around a medicine man in the center. Now and then one of these people would seem to go into a trance, or would assume a very strange posture, with a wild expression, and would seem to talk to someone who was not visible.

Later, a tour of the village revealed a high proportion of persons, both infants and children and adults who were deformed somewhat like the "thalidomide" babies in Germany, with missing arms or legs or deformed heads. The proportion of deformities was found by the research team to be ten times as high as would be found in a group of the same number of persons from other areas of the world.

Interview Number 1

Interviewer: I'm your library and your laboratory. I'll attempt to give you answers if I know them. So now you just go ahead with this situation and see how you would work it out.

Student: What do you want me to do now?

I: Just go right ahead and try to figure out the problem that is stated there and ways you would approach it.

S: Tell you how?

I: Yes.

S: I'd go see if any drugs, any kinds of drugs were present that they could get a hold of like pot or something that could affect the child's birth, make him deformed or something.

I: All right, how would you do this?

S: Probably look up and see where the drugs maybe could be found in that part of the country and what kind.

I: All right, what would you look for particularly here? I mean from the information, what might you suspect here? What channel would you go in? Analyze what the people were doing, see if that gives you some hints.

S: They might have been drinking some form of drug or smoking it.

I: All right, now pursue those a little bit. In other words you suspect something now, so now go ahead and pursue it and find out definitely what you might suspect here. In other words you're presenting a hypothesis. Now let's see if we can prove it or get any information on it.

S: If I want something, I'm supposed to ask you about it?

I: Yes, if there is some information you want to know concerning...

S: You could tell me what kind of drug...the possible drug that could affect the people that were being born there.

I: Yes, there are many kinds of drugs that will cause abnormalities in children. We call them teratogenic agents and they range over many many different kinds. Thalidomide is only one of them and is used just as an example because it's a common one. The people there as you see are in a ceremony of some type and we're getting some peculiar reaction from some of them. Does that indicate anything?

S: Maybe try to get a hold of something they were smoking or drinking and have it analyzed.

I: Good, now have it analyzed. Now you're bringing in a laboratory. You've got a number of things so what might be one that you would want to pick out and chase down to see if...

S: A drug.

I: All right, and from what they are doing which one would you like analyzed?

S: What they were drinking.

I: What they were drinking. All right, we analyze what they were drinking and find out that it's the common drink of all the people in Central America, basically fruit juices with cactus and so forth. Sometimes they let it ferment and it becomes alcoholic. It is used by most of the people throughout the area not only these little colonies.

S: It would probably be what they are smoking.

I: All right, how are you going to approach this?

S: You could have it analyzed. You can't analyze that, can you?

I: Yes, it's possible.

S: I would find out what was in it. Maybe I'd look at somebody that lived there that had died. Look at them and see what's wrong with them, like their lung or something.

I: Would you want to analyze the individual or would you want to analyze the product or the substance that would be smoked? You've got two situations here; let's pursue one of them.

S: Probably the substance that he was smoking.

I: All right we analyze the substance. And he was smoking a substance we call peyote which is made from a cactus plant.

S: That's a drug though, isn't it?

I: It's a drug.

S: It's a hallucinatory drug.

I: It's an alkaloid, yes.

S: I'd probably think maybe that was the cause of it...what was causing the deformation of the people...it might have been what was causing it.

I: All right. You think this might be right, now what are you going to do with it?

S: Might try an experiment on another specimen like...not a human, like a dog or something like that. Feed him some small amounts of it and after a while see what happens to him.

I: Would you suspect that if you ate the material that you would get the same result as smoking?

S: Possibly, I think maybe so. I don't see how you could have the animal smoke it though.

I: Keep going on this. You've got an idea that this is the stuff that's doing it how are you going to find out for sure, or how are you going to look into it to see whether it is this substance or not? You mentioned feeding...

S: Might try and burn it and let them breathe the smoke from the peyote. It would be almost like smoking probably.

I: How would you do this, now you've suggested animals, how would you go about doing this?

S: Put the animal that you're testing in a room and burn the peyote and let the fumes go into the enclosed room so...

I: Now do you use just one animal?

S: No, you'd have to use more than one. There would be about...probably test a female and a male...two or three males, then give each one...you'd have to have negative set, and give one set so much and the other set a little more. See if that affects...how much he gets if that affects him. How much more time you spend smoking than somebody else might have worse effects than they would...I guess smoking every once in a while rather than all the time.

I: You'll notice on the sheet where there are abnormalities occurring in normal individuals, or it indicates, suggests this but the ration is 10 per cent more. What would this mean as far as your experiment is concerned? You have set up, as I understand it, maybe a number of dogs, one where you use a heavier concentration of peyote as against another one where you use less. Do you need any other groups?

S: One that didn't get any at all.

I: All right, this is good. You do this for a period of time; then what did you want?

S: Compare the results.

I: What would you be looking for? What would the results be? Where would you look for results?

S: Life span, I don't know...probably birth effect and the condition they are in after the experiment.

I: Do you want the results of that if you did that? You're looking at the dogs you put in there, they all look normal.

S: They would all look normal?

I: So now what would you do? The abnormalities that you find indicated here are expressing themselves in what groups? As far as these groups here are concerned?

S: The deformaties in the young.

I: Now go back to your experiment. You wouldn't see any results in those dogs. You wouldn't see any difference in them. So where would you go from there?

S: I wouldn't know where to go.

I: You see the abnormalities in all different age groups, but how did they get into the age groups? Where do you first get the abnormalities appearing? As far as age groups?

S: In the young.

I: Can you associate that now with this experiment that you set up? How did those young individuals get those abnormalities?

S: From their parents.

I: All right now back to your experiment, let's see if your experiment you set up is valid.

S: You told me that the dogs that would be born there wouldn't be abnormal.

I: You didn't ask me that.

S: That's what I meant though. I said in the births that maybe the dogs would have something wrong with them.

I: All right in the pups that were born. Is that what you're asking now?

S: Yes, would they be normal?

I: This we don't know specifically, whether they would or not because we haven't that much information on it as yet. But from what you have set up, how would you go about knowing definitely? I say we don't know because there hasn't been enough work done on this. What should be done to go further to identify this, can you think of anything in this area?

S: What should you do now that...probably just keep experimenting maybe with some different animals instead of dogs...maybe monkeys or something.

I: All right, monkeys might be good, why?

S: Well, they are supposed to be closely related to humans.

I: Would you think of any way you might improve your experiment? You have the dogs set up and you are burning the material and having them breathe it. Do you get the same results out of breathing tobacco smoke that you would get out of smoking the cigarette?

S: No. I would hate to have them smoke it though.

I: Again I'm here to give you some help. Do you have any questions you want to ask about this.

S: Is it possible to get monkey to smoke this?

I: Yes it is. You could train them to smoke.

Interview Number 2

Interviewer: Use any way you want to see how you could solve this situation or look into it to see what is happening. I will try my best to answer any type of questions you have or give information you need for working on your particular problem. So now you just go ahead and find out what you would do about this particular situation.

Student: First I think I'd want to know about thalidomide. The missing arms or legs and the deformed heads, those are the only characteristics of thalidomide?

I: These are the main characteristics, yes.

S: Okay, then I'd take what they were smoking and drinking and find out what was in that...what exactly would be causing the thalidomide babies, if anything. So could you tell me what was inside it, like if I were going to examine it or break it down?

I: Just how would you do this.

S: Let's see, I'd find out...a medicine man, he'd probably mix it himself. So I'd probably watch him mixing it or something and find out what he puts in it and what proportions. I'd try to figure out what the outcome would be with these certain things and certain proportions that are put in.

I: All right, I'm your laboratory but you have to set up a way so the laboratory knows what you want to test for and perhaps why you would go about it. Now you're concerned with what?

S: What would be contained in what they were smoking and drinking.

I: Let's separate smoking and drinking and go from there.

S: I think I'd want to know if possible the thalidomide baby...if like that could be passed on from the...the tendency for the missing arms or legs could be passed on from generation to generation.

I: What would you have to do to find this out?

S: You could take someone who is like that and trace their ancestors or take their children, their dependents. You could find out if it's a recessive or dominant trait which would carry over.

I: You system of doing this would be what then?

S: It seems like if you trace someone's...like wouldn't that work if we traced someone?

I: Are you talking about pedigrees, talking about children of affected children?

S: Like one that the disease...

I: This would be one way, yes.

S: Okay, and if it would be hereditary, pick it up from parent to parent....I wouldn't know how to break down what they are smoking. Couldn't you just examine it, see what components it has, what effects these things separately would have and if you combined them, what effects they would have together?

I: You've talked of smoking. You want to find out what they are smoking?

S: Yes.

I: I can tell you what they are smoking; among other things, they are smoking part of a cactus plant which is known as peyote.

S: I'd have to find out what is in the peyote cactus.

I: How would you do that?

S: Couldn't you take a piece or a seed or whatever it is and test it under various circumstances? No, you'd take the circumstances that it would have grown in in that climate in Central America and then you could dissect or take a piece of that.

I: Would you need to do that actually? You mentioned testing it. How would you test it? We've got peyote now. What would you go on from peyote, what is it?

S: A cactus plant.

I: That is what you want to know, what is it? Remember, I'm your laboratory.

S: So I could just ask what a peyote is?

I: Yes, a peyote is mescaline which is an alkaloid. This is a hallucinatory drug.

S: That would explain what why they go into trances and the weird positions that they get into and the wild expressions and talking to somebody that isn't there. If you know what the peyote contains, then you'd know that it affects the way they act. But there would have to be something to explain the missing arms and legs. That would have to be something they are drinking or the combined effects of both of the things, the smoking and drinking. Also environmental factors would be awfully important. Somebody could probably smoke this like in Central America and it would be a lot different than in Kansas City. Maybe if we did it it wouldn't affect us quite as badly because we have other things. So if we know what is in the smoking we have to find out what they are drinking now. Do you know what they are drinking or can I ask that?

I: Yes, remember you have to feed the laboratory what you want.

S: Okay, I want what they are drinking is made of.

I: Basically alcohol from various fruits and so forth that they usually ferment themselves.

S: They usually...would you repeat that?

I: It's a mixture of fermented fruit material, cactus and things of that type, but not the same cactus that is used for peyote. Which of course, as many when fermented becomes basically alcohol.

S: Then the fermenting fruit has something to do with it. Wasn't there alcohol in their smoking content? There wasn't? Well if the smoking is for the trances and hallucinations and drinking the fermenting fruit... lets see, I don't know...this is probably real far away from it, but fermentation is an absence of oxygen, right? Then where they have had their arms or legs...like the cell...no I don't think that. I forgot where I was.

I: The drinking?

S: Yes.

I: I mentioned that it's a mixture of fruit, cactus and so forth which is used for their drinking. It can ferment and become alcohol.

S: I think that once that you've found what was in everything and what characteristics the thalidomide babies had, I'd want to go down and observe them and find out what other routines the people have. Like do they have any other weird rituals, what else their intake is any weird food besides what's supposedly their smoking and drinking. If you found out, you could make a blueprint or something of their life, I mean like their daily things, like what they do and find out what else they take in. Then you'd...they you could see if it was just the smoking or what they are drinking.

I: Would like to break that down and maybe we could get some of it.

S: You mean act like I'm there observing them?

I: Yes, in other words I'm your source of information now. If there is something you want to know, ask me.

S: Okay, I want to know what they eat, is it all wild things?

I: Their food is basically the same throughout the whole area: fruit, animals such as pigs and chickens and things of this type. It's as good a food you might say as we have here. There is a little malnutrition but basically the diet is enough to give the normal things that they need.

S: I want to know if they are active people, fairly active or just kind of sit around?

I: They are fairly active.

S: Do they live real primitively still...I know they have the medicine man there but...

I: They are primitive people, often living in shacks or huts or things of this type.

S: So there's no real sanitation at all.

I: Sanitation is not the best, no.

S: Their diet is sufficient for giving enough of what they really need, but it lacks a lot of nutrition. Was the baby kind of weak? If malnutrition... it would be small, small-boned, or are they like that?

I: They may be undernourished partially or they may be thin. However, they are normal as far as the people of that area are concerned.

S: Also, in this one little village, is this the only place that they drink and smoke?

I: There may be some several little villages, but they are all isolated. The whole population doesn't do this.

S: Oh, it's just like separate groups? Well, it seems like I didn't get anywhere with that.

I: Why don't you pick out one of those things that you might suspect as being the cause of this difficulty and chase it a little further.

S: The one about their life after I've observed them.

I: Yes, You've been observing them now and their food is fairly consistent throughout the whole population, housing is fairly consistent throughout the whole population. Is there anything you might want to follow that might not be consistent?

S: Probably the only thing with their food was malnutrition...but I think it's like the cleanliness wouldn't have that much to do with it because you know they are still taking that stuff into their bodies. I don't think sanitation would have much to do with it. I think it would probably be the lack of nutrition in their food, because if their body was weak and doing things like...they would be more susceptible to...

I: Hou would you determine this?

S: You could take two groups of the people, two small groups and let one live just as they were and then one on a more nutritious diet and then still let them take on their normal things, like their rituals and if in the group with a more nutritional diet, if less people came out as thalidomide babies then I think you point to it as lack of nutrition in the food. But if there was none you'd just have to start again somewhere else. You'd have to keep the controlling factors all the time and you'd have to have a control or you'd never really know what was causing it.

I: Supposing you did this, you want the results. The results would be throughout the general area that the food is about the same, perhaps a little bit different but basically the same to all the population, whether it's these little groups we're talking about or the general population. There's not a great difference as far as the food is concerned.

S: If we put them on a more nutritional diet there would be about the same results?

I: Those that had a more nutritional diet would look more healthy of course.

S: These thalidomide babies, is there any special...or is it just coincidental... not coincidental but accidental, I don't know. What I mean is some people in certain parts after they get colds...these thalidomide babies is there any way to...have more of a tendency to hit more people with?

I: How would you approach this to find out?

S: You'd have to go to a cross section, take two countries...take like the world...in Central America, you could take another isolated village a little bit further away and find out if there is such a high rate in another village that had no contact with anybody else as did this one here.

I: Now let me clarify what your saying. You want to take this one little colony that it mentioned here and compare it to another group of people elsewhere and what kind of a colony would you want to compare this one to?

S: One that hasn't got exactly similiar things because you'd want to know what factors all combined are causing the high rate babies. So first I would have said take one in Central America, but it seems like you really couldn't because everybody is consistent like you said, you know the food and everything. If all their environments are about the same in all the villages, I think you'd like to check somewhere else to find...what I really want to find out...this known for having more than another class so that you could maybe find something there that would have more clues as to what was causing it...I don't know much about...

I: If there are more abnormalities in the children there then elsewhere, is that what you want to know? That is the arms, legs, so forth.

S: Yes.

I: Percentage is greater in the village than it is elsewhere or villages of similar types. I think its about 10 per cent more. Is there something there you can see that might be different and might be over the other population? Is there something there that you can diagnose in that little problem that might be different? You've approached one area. Do the same thing perhaps with another area.

S: Do all these people drink and smoke the same, whatever they are drinking.

I: How would you determine this? Could you give me the process by which you might determine this?

S: Well, you could just observe another village and see their routine, like if they include the smoking and drinking.

I: May I ask what kind of another village would you select for your comparison?

S: You'd have to have one that lives the same way. You'd have to almost duplicate the people except put them somewhere else, like if they are more isolated then the people in this village if they were isolated they never could have gotten anywhere else...I mean using it all the time...I mean just kept it central right there.

I: So the question you want to ask is--remember I'm your library, I can give you the information.

S: I just want to know if the people in other parts of the village, in the other villages in Central America lived the same kind of life that these people did in this village? Did they have these rituals, did they smoke and drink the same thing?

I: Some of them do, yes.

S: And is the rate there of these thalidomide babies just as high or not as high?

I: Those that have the same rituals have the same.

S: The same rate? Well then you have to point to that and say that's their really...

I: You've talked about whole populations which are different as far as diet is concerned. Start narrowing down the different things. We mentioned diet saying that doesn't have anything to do with it. Are there some other things that might, that you read there?

S: Their arms and legs, I mean the absence?

I: Your problem is trying to find out what causes that, isn't it? Can you see anything that might lead to this?

S: Medicine man.

I: The medicine man, probably not. But were there other things they do, you mentioned one thing there that we got into and then you stopped...

S: You mean sanitation?

I: How would you work on the sanitation?

S: You could take two villages again, one this one and one another one like it and the second one had not good sanitation and see if anything, see if the results were the same as in this one village here. That doesn't make sense though.

I: Would you take another village or another group of people which could be a village?

S: In a way it would be good to take someone out of that village that had these thalidomide...you know in the same deal as we're talking about here, take someone else and take a small percentage of those people and bargain with them, because they would have been exposed to all those... well, I'm just running around in circles.

I: There is something they do there that...

S: In here?

I: Yes, in there, that is not usual for people.

S: Would it be trances and things they go into?

I: All right, now push that.

S: The smoking and drinking would have to affect their minds in some way for them to act so strangely or maybe like the smoking is a hallucination effect and then combined with...isn't there alcohol...when you get drunk you lose your head, you get real high. It seems the things that were combined in there will cause them to take the strange position and go into trances. That doesn't say too much does it?

I: Is there something there that might lead to these defects in the children? This is the thing you're after.

S: I'd say, like if they were in trances, what connection that would have with losing an arm or a leg...under the effects of something or damage themselves some way. But that wouldn't be right because you can't pass on traits like that...like the mother doesn't have an arm that isn't passed on.

I: Did we decide what was in those substances, in smoking?

S: It was peyote, the cactus, and in drinking it was fermenting fruits and cactus and alcohol.

I: What about other populations in this area?

S: We said that they lived in the same way, they had the same food and things, but in this village it was higher, these thalidomide babies, a higher rate.

I: We mentioned food, did we mention anything else?

S: I don't know about sanitation. We never figured anything out for that did we?

I: Was there anything mentioned about the two you were talking about a minute ago? The smoking is there. Would you think that smoking might have something to do with it?

S: To do with these babies? Yes, it does. That's why...you mean like what other effects the things they are smoking would have?

I: How would you approach it to find out?

S: You could take someone in this environment and have him smoke those things all the time and take somebody else that doesn't smoke them.

I: Fine, is there any other way that you could find out without doing that?

S: Well, we checked on other people and in the villages they smoked they had these thalidomide babies and the ones that they didn't...

I: Did we check all of them. Your question wasn't set that way.

S: No, we just checked two.

I: How would you then...

S: Well, I'd want to know that in the places where they smoked, did they drink too? So was it the two of them working together? Was their village where they just smoked and didn't have these thalidomide babies or were there some villages where they didn't have...

I: You have to divide that and set it up. Now your asking me multiple questions here.

S: Is there any village that just smoked the things and had the thalidomide babies?

I: Now, as against another village that did what?

S: I mean a village that did both smoking and drinking compared to one that just smoked, and then let's say one that just drank so you could see...

I: Now which one do you want the answer to first.

S: The smoking.

I: The one where one village smoked and the other one didn't?

S: One smoked and the other smoked and drank.

I: There would be no difference.

S: And the same would be for a village that drank and one that smoked and drank?

I: No.

S: So there would be no difference. No.

I: Ask the second question again now and pause at the end.

S: Okay, you want me to ask the second one again. If you had one village that just drank and compared it to another village that drank and smoked would the results be the same?

I: No.

S: They wouldn't. Then it is obviously something they are drinking and there was the fermented fruits...

I: Now I want to trace that back again because, make sure as you set up your program that you set it up so that you can discern...see you've got two substances you're working with now. This always make it more complicated once you cut down to one.

S: Where we compared one village that drank to one that smoked and drank there would be the same results, isn't that what you said?

I: In which colony?

S: In the one that just drank.

I: Less.

S: Less. Well that reverts back to the smoking, so you know it was something they were smoking because comparatively the ones...I get myself confused... yes, I was right--it would be the smoking that has it.

I: All right, now go on from there. That's fine.

S: The individual effects of the smoking were the hallucinations.

I: Yes, this was one effect.

S: Are there other effects of it?

I: How would you find out?

S: You could find out...you could test...no you wouldn't do that. Well you could if you want to find out what other effects it has...you could take a...I'm trying to think of what I'm trying to say.

I: We do experimentation in many areas. Is there any---

S: You mean test on something nonhuman?

I: You've isolated pretty well to, perhaps, smoking. Now you need to find out definitely whether the smoking of this material is the thing that does it. But you have to prove it. You need to go further and try to see if you can set up a system by which you could demonstrate this effect you have.

S: Could you take a group of people again and have them smoking, just smoking, not drinking, and going through the regular routine, and then have another group that has the routine but doesn't smoke and then you'd have to let it go for a while because you'd have to trace...because it says here that infants and children and adults...you'll have to take a while with

your testing...you'd have to go through three stages and see what else would happen to them, like would it be other than the trances and stuff?

I: Demonstration with humans is rather difficult because of laws and so forth prohibit it.

S: Take animals like mice or apes because they are kind of close to us.

I: Fine. Now we're going to push that a little ways.

S: Okay. I wouldn't know whether to bring the drinking back into it or leave the drinking out all the way. You could have a smoking and drinking set up with some, and those just smoking, but then I don't think you'd ever...yes, you would because this village is using both of them. And if you just put somebody on smoking you would find out what else happens besides what you know has already happened in this village where they were drinking too. So you could set it up that way, couldn't you? Okay, take those results...something else was happening like I don't know what it would be though.

I: Let's stop right here just for a bit. Summarize on what you have done, what you've found out as far as this problem is concerned.

S: First I had to find out what was in the smoking and drinking. You told me in the smoking it was peyote and the cactus, and in the drinking it was the alcohol. The smoking caused hallucinations. In drinking it was fermenting fruit and cactus with alcohol and we found out that first you had...the area we were testing, we found out that all through the continent that everything was consistent, everybody had the same food and living conditions. But there was just this one village with this excessive smoking and drinking of these things and who had the thalidomide babies so then I had to isolate and I found out the smoking was most probably the cause of the deformities in the children and the effects that it has on them because when we took out the drinking element there was a lot less or was it none? Was there none or less? It was a lot less in the villages where they smoke and drank. Then we had to set an experiment where you could test and find out what the other effects the smoking has on the people.

Interview Number 3

Interviewer: Take the pathways that you feel you would need to try to help solve or find out what is wrong and what you could do about this problem.

Student: The problem says its like their smoking and drinking and they have a problem of physical deformities and I think first to solve the problem, I would try to find out what it is, analyze what they are smoking and drinking to find out if it does contain thalidomide or something similar to that.

I: How would you go about this?

S: I would probably take a sample of what they are using or go to its natural habitat and take a sample to a physicist or a pharmacist or someone who knew about this and have him analyze this and find out what elements it contained that would maybe be harmful to children.

I: All right, what would you be interested in particularly? What substance?

S: I think first in a case of this I'd look for thalidomide and if there was none of this in the tobacco or whatever it is, I would look for something similar to thalidomide.

I: Remember I'm here as a source of information, so if you want to know anything about those why...

S: If the pharmacist or whoever is analyzing this element...well I would find out what it could cause, look it up in an encyclopedia. If it was thalidomide, I'd look it up and see what kind of deformities it could cause in an unborn child and then I would take and make a report of this and write down what it would cause and then if it was the thalidomide they were using in this substance I'd find out what exactly it would cause in unborn children.

I: Do you want to know some of that information?

S: Yes.

I: What would you like to know?

S: Does thalidomide cause...what things besides thalidomide could cause deformities like missing arms, like they are not completely developed?

I: Yes it can cause it.

S: And I'd find out if there are any other substances besides thalidomide, similar to it, that would cause this same thing.

I: Yes there are quite a number of substances that can cause this.

S: Then I'd...what would a few of them be?

I: Oh, sometimes we find such things as lack of oxygen causing it, or overabundance of vitamins or various substances of all kinds, cold tars and things of this type could cause abnormalities in a fetus.

S: Would there be any other substances like tobacco or some sort of a grain that could be made into a drink or something to smoke that might cause this outside the body?

I: Yes, actually there might be several that would do this. What particular kind would you be interested in?

S: I'd be interested in something that would be very similar to thalidomide that would...that they might have in Central America where they could pick it and make cigarettes or some sort of drink out of it, that once in their system would cause this.

I: Now you want to tie this down to specifics as what your referring to from the problem and maybe I can answer some of your questions.

S: I'd like to find out what kind of plant they would have in Central America if they made it into something like a cigarette or they could drink it that would cause them to react or go into a trance like they might do on marijuana.

I: Now, shall we confine it to one road first and...

S: Let's see, I would first find out what plant would be the cause..if they were smoking it, you know something similar...

I: The substance they were smoking in this case was peyote made from a cactus plant.

S: Then I would find out where this...what kind of conditions this...find out about the habitat of this cactus plant.

I: This grows wild.

S: And I'd find out how they would process this plant because sometimes plants themselves are harmless but a certain way of processing would cause them to become a drug of some sort, and I'd find out exactly how they dried it and rolled it so they could smoke it like a cigarette.

I: This plant is just dried and rolled.

S: You mean they just lay it out flat and roll it up? Then I would find out what elements this plant would contain, like if it does contain thalidomide or anythink similar to that and break it down.

I: Actually the plant contains a substance which is mescaline and it has some peculiar effects on individuals.

S: Then I would go and look up mescaline and find out what kind of effects it would have on certain people and what sort of effect it would have on an unborn child and what kind of plants...

I: Let's take one at a time now, which one would you like to know?

S: First, I would like to find out what kind of effects it would have on a person using it at the time.

I: Usually hallucinations.

S: I think I would go first to an encyclopedia, an informative encyclopedia and look up this substance and find out exactly what kind of effects it would have on an unborn child and if like they referred me to another encyclopedia I would continue and find out exactly what this does to a fetus and to the people who use it.

I: You wouldn't be able to find it.

S: If I couldn't find it in an encyclopedia, which I would definitely try first, I would probably go to someone who is informed on it, like a scientist or a doctor.

I: You're the scientist now, so how would you approach it?

S: The mescaline I think I would take to a pharmacist and analyze it so I could find out what elements it contains and then I would probably take it to a doctor who is experienced in deformed children and the causes of this and who would know about the mescaline and would be able to tell me what kind of defects it would cause in the unborn child.

I: The doctor probably wouldn't be able to tell you. Now how would you approach it if you had to solve it yourself?

S: I think I would study these people, the women especially, younger women like teenagers and young maturity and I would study this and after I had studied how they react to this drug I would go on and study them once they got married and got pregnant and watch the children and find out a percentage of how many are born deformed of these girls who have used this drug and the percentage that are born normal. Once I found that out I'd make a chart, and once I'd gotten this percentage I'd have it all written out and study it a little. If I found out that it was, I'd take for a control a group of girls who hadn't used this along with the girls who had and keep them separate and not have the girls who hadn't used it use it at all before they get pregnant. These other girls who normally do, let them go on and use it. If the girls who have used this drug come out with 50 percent deformed and these girls who don't use it have maybe 50 percent deformed children anyway, I'd find out if maybe the males...maybe it was connected with the man too...takes like two people to cause it because sometimes the drug would affect a male sperm in a way that could cause the child deformity too. So I'd study that and get a percentage like if they are married and they smoke and... well take the girls who don't smoke and let them run around with guys who do use this mescaline and do the same thing with the girls who do use it and if the girls who don't use it and the boys who do use it still come out with like 50 to 60 percent defomed children I'd know that a lot of it is the males cause and...

I: In as much as you're working with humans which are kind of interchangeable as far as attitudes are concerned, could you think of another approach to the same thing, that you could make without using humans? The human element is sometimes unpredictable as to what they will do.

S: I'd like to take the old standby guinea pigs and innoculate them and watch and study their results.

I: You're concerned with what substance?

S: The mescaline.

I: Remember your mescaline is coming in two different sources in the problem you set up here. It's coming from smoking, that's what you were using in your human element. In your guinea pigs you inject it. Now I just make this comment, that if you do the same thing with nicotine and you're extracting it from a cigarette and inject that amount into an individual it would probably kill them. Maybe the same thing would happen with the mescaline if you would inject it.

S: If I came up against a problem that would kill them if I did inject them with a certain amount...it seems kind of far out, I'd probably fix up some apparatus where I could get the smoke from it or something like that into their surroundings. Put them into a box of some sort, and get into a surrounding like a person when they smoke all the smoke and everything and then watch them. If the smoke is what caused them to do...collapse then I could tell it was probably the inhalation that would do it.

I: Often we find that we haven't anything to compare them to. See in your previous one you had some comparisons.

S: In any experiment like this, I'd have control animals, like guinea pigs, that I didn't put in a surrounding like the ones in the surrounding where the smoke was coming in the area. I'd put them where it wouldn't bother them. I'd probably check them when they first start to get with the guinea pigs that were in the little box. I'd check them maybe every half hour to an hour to see what the effect on the animals at that time would be like, like they would collapse or start going crazy and after that, if that didn't have that much of an effect on them, I'd check them only maybe once a day or twice a day or so and I'd watch the results and balance it against when they get pregnant and have the litter. I'd balance it against the results of the ones that were in a normal cage, healthy and I'd balance it against the ones that were in this enclosed box and check the results on that and compare them.

I: Now would there be any numbers that might be of significance?

S: You mean like male or female in this one area?

I: What I'm talking about, would you use just two animals or a dozen?

S: In this closed box I'd take an equal number of males and females, maybe four or five of each, and then I'd do the same thing in this other box. Even in animals it will have a different effect on each animal because

of different body structure and I think, after the first maybe half hour of this smoke in this area, I'd separate them into their own boxes and keep this up for a while, for a set length of time in periods. I wouldn't do this constantly because it would probably kill them, constantly breathing smoke. I'd put like a male and female in a box and a male and female in another box until I had them all set in pairs and I'd have these others set aside in pairs too and I'd watch each pair of animals and the litters. Maybe some of the litter will die of the ones that were in the smoke and I'd take that and write down like so many died of this many babies; and then I'd write so many had only three legs or two legs; so many had strange deformed heads. And on the others that didn't have the surrounding I'd do the same things--that would be the ones in the cages. I'd balance them out and see, is it this smoking that's causing this and the others is it...I guess is it normal...you know it's normal to have a certain number of deformed babies, children whatever, because it just happens that way.

I: Let's come back to humans again. If you're sitting in a room where other people are smoking, do you think you would get the same amount of materials from the smoke as the individual would who is doing the actual smoking?

S: You get a certain amount from the smoke itself but I don't think that it would be as if you took part of the tars and nicotines and what not and innoculate it. It's a small percentage. If you were actually smoking, it's when you inhale you get a lot of smoke down in your lungs and its got all these tars and stuff in it and this remains in your lungs so you get more if you're actually smoking it. But it's kind of hard to get a guinea pig to smoke a cigarette so...

I: Can you think of another animal that you might use?

S: I was thinking maybe a chimpanzee because some sort of a monkey... the closest monkey you can get to a human being which is, as far as I can tell, a chimpanzee or some sort of ape. Chimpanzees are easy to train so you can train them to smoke. I'd give him this kind of cigarette they are making with this mescaline and have him smoke it continually, hour after hour, day after day, but in periods. Give it to him at a set time each day and then watch the effect it has on him because if it reacts anything like marijuana it immediately...very soon after they start smoking it they go like into a trance. They'll start acting strangely, not like a normal ape would act, and I'd observe this. I'd take a male and a female just one this size and then take a male and a female that were not smoking this and if they have babies I'd watch it and see if it's deformed like if it has only three...only one arm and two legs or it's missing an arm or a leg or its head is deformed. I'd have to watch them for maybe as long as it would take them to have at least three or four babies because sometimes the deformity will be caused just from natural causes, not from the smoking and if after three... no maybe four babies they've got at least three that are deformed in some way--missing an arm or a leg--then I would know that in some way the smoke... it was mescaline in the cigarettes they were using that was causing this,

and then once I had gotten this set that it was the smoking that was causing this deformity will be caused just from natural causes, not from the smoking and if after three...no maybe four babies they've got at least three that are deformed in some way--missing an arm or a leg--then I would know that in some way the smoke...it was mescaline in the cigarettes they were using that was causing this, and then once I had gotten this set that it was the smoking that was causing this deformity I would in some way try to prevent the use of this drug when it was finally...well it would take a while but I'd get it set down pat that I could say exactly that it was this mescaline that was causing all these deformities. Once I did that I could go ahead and try to get the people to quit using it, because it's causing this.

I: Fine, now go back and review step by step what you did to come to the conclusion you made.

S: I started out with a problem, the people were smoking and drinking this mescaline that they had made from a cactus plant and that was causing deformities of the children so I took an ape or some sort of an animal similar to a monkey...took a pair and had them use this drug, smoke it, drink it, what not, and after studing the children, after studying the results of this and having concluded that it was the smoking...that the smoking was causing...the mescaline in the cigarettes was causing the deformities definitely, I would go ahead and get rid of it.

Interview Number 4

Interviewer: I am just here to help you as a library or laboratory for your answer to specific questions on material that you might need. So you just go ahead on the problem and work it as you feel you should or approach any way you wish.

Student: What were these people drinking?

I: You mean the actual substances they were drinking?

S: Was it alcoholic?

I: This is a drink that is made by the natives themselves which contains fruit juices and cactus juice and various things of that type and can be fermented and could have some alcohol.

S: They only drink this during a ritual?

I: Yes, basically. Can you see what the problem is and try to figure a way out?

S: The problem is that the villagers are deformed and we're supposed to find out what is causing the deformities.

I: Yes, now approach any way you wish to try to get to the basis of what you might think would cause the deformity. You mentioned the drink situation. This is an idea. Now what would you do about it?

S: I'd find out how far this ritual went back. If it went back as far as anybody can remember it could be an explanation as to why these people are deformed. What does this word mean?

I: That's thalidomide, a drug that was the cause of some abnormalities, particularly in Germany and in Europe. It was given to the parents for other treatments, but it turned out that it caused these abnormalities in babies.

S: Does this thalidomide, does it mean similar to the drink?

I: How would you find out whether this was?

S: You could take samples and analyze the chemicals.

I: You're asking me whether this drink does have thalidomide in it. No, it doesn't have; this is just an example use.

S: These people who go into trance--they only go into a trance once and then come back to...

I: No, this may occur several times. They may go into one, come out of it, go into it again.

S: Has anyone died in the village of natural causes, besides natural death, like poison or anything?

I: Let's say only that might occur by accidental poison or something of this type.

S: What sort of a posture would they take?

I: On, bizzare shapes, kind of twisted features, things of that type.

S: Seems like if you'd take maybe a blood sample, some sort of sample to analyze what's wrong with the people, you might be able to find out why the people are deformed.

I: What would you be looking for? Blood has a lot of stuff in it. Is there any particular...?

S: Any drugs that are not usually found in the blood.

I: All right, is there something you suspect might be there? A laboratory, if you send in blood, always wants to know what you are looking for and then they can test for it.

S: Since it's Central America, I believe marijuana and stuff might grow freely and they might be smoking it, which would cause some of the trances and would also explain some of the deformities. I don't know if it's proven or not, but it's a theory that marijuana and drugs might change the sex organs or the genes or chromosomes of the person using them.

I: All right, good, maybe this is an idea. How would you apply it to this problem here.

S: Suppose if we had a long time maybe we could have some people smoke and drink the stuff in the ritual and we could have some that would not participate in the ritual and see what their native generation is. If the smoking and drinking only change the person over a long period of time that wouldn't do any good because this has all been during one generation.

I: Is there a way you could get this information without too much difficulty? What about other people in the area that do not belong to these little colonies?

S: Well, you could observe the difference between them and maybe if the other tribe didn't do all this stuff, it would seem pretty likely that the smoking and drinking had an effect on the people, if they were the only ones that smoke and drank and they were the only ones that were deformed then it could be proof that the smoking and drinking had an effect on the tribe of people.

I: Normally we find in populations a certain percentage of abnormalities. How would you proceed on this now?

S: In Central America that there were a certain percentage with...?

I: Yes, what I mean is this, if you took the whole population you would find a certain percentage of abnormalities and then in these colonies you may find a different percentage of abnormilties.

S: In the colonies, what do you mean the colonies?

I: Different colonies of people like this.

S: Oh, I thought you were thinking about taking a percentage of all Central America and compare it to different...other...

I: You can do this too, but in any normal population, you will often find a certain number of abnormalities.

S: Really it would seem reasonable that the tribe or colony with the most malformations or deformations would think there might be something to do with their eating habits or something like that.

I: So you've suspected it, now what?

S: Well you could...

I: You can see these abnormalities, you think there is something causing them. You mentioned food, you mentioned drink and tobacco or smoking things of that type. Are all of them doing it, maybe one of them? How can you get to this problem?

S: Make a list of what tribes do what, of their habits and compare them. Maybe the ones that do the most smoking or drinking are the ones that have the most deformities, the ones that are more active might have the least deformities or something like that.

I: Where would you get that information?

S: Go around to the tribes and study the people and make a list.

I: All right, I'm your library, you could look it up in the library or you could go and find your laboratory if you want to ask me on that question. Now state specifically what you want to find out.

S: Can I ask you the differences of the eating habits of the people, or do I just have to ask what one person eats in every tribe?

I: You could ask basically what the difference is?

S: What's the difference?

I: Pretty much the same throughout the whole area where these people are found. The eating habits show very little difference.

S: Do they all smoke?

I: No.

S: Just this tribe?

I: There are certain colonies that do and others that do not.

S: What were they smoking?

I: They were smoking a substance known as peyote which comes from a cactus plant.

S: Does it have any effect on the people?

I: Yes it does, its hallucinatory.

S: That's all it causes, just hallucinations?

I: Basically.

S: Does it have any far reaching effects like malformation?

I: How would you determine this?

S: Might test it on some animals.

I: Keep on going.

S: Inject...I don't know how you would do it, but someway make the animals smoke the plant.

I: Can you think of an animal that you might do this with?

S: Rats or animals that will generate pretty quick. It won't take over a long period of time for it to reach two generations. You could test it on these animals and have an equal number of the same kind of the same family if possible and have them on a regular diet and have the other ones taking the cactus plant and see what the differences are.

I: In other words, you'd take one group and do nothing with them and another group and have them smoke. Do you know of any animals you could have to do this? In setting up experiments of this type you have to take into consideration what you can use and so forth. You'd do a lot of work on the animals too.

S: You might be able to take some secretion from the plant and inject it into a rat. Can you eat the plant and have an effect, like an hallucinatory effect, or do you just have to smoke it?

I: You don't get the same results usually.

S: I suppose if you want to, you could try it on a human.

I: They usually won't let us do that will they? I'm here for information so if there's anything...

S: Is there any way that you can, instead of smoking it, put the effects of the smoking into a capsule or something that would give the same effect.

I: You could extract the materials from the peyote just as you can extract nicotine from a cigarette.

S: Extract something from a plant and inject into the mice and see what the differences are between the two groups.

I: May I say this: You do this with nicotine and the nicotine out of the cigarette injected into the human would kill the human.

S: A small amount wouldn't kill a person would it?

I: It would depend on the dose, yes.

S: Inject an amount that wouldn't kill, that would only stimulate the animal and not kill it.

I: What would you suspect might happen now?

S: I would suspect the next generation would be deformed or hair could be off-colored or all sorts of things could happen.

I: You would have two groups of mice?

S: Yes sir, same feeding habits except...

I: Fine, now could you think of a corollary experiment maybe with some other animal that might do the same thing, that might get you closer?

S: Can I do it with a monkey of some sort? I think they're pretty close to the human.

I: All right.

S: Well, if it happened to them the same as the mice...

I: Would you run your experiment the same way?

S: Yes, two groups, and everything the same except that one group would be injected with a small amount of extraction from the plant. I guess I'd test that a couple of times before I'd make a solution.

I: Then you would look basically in the offspring for what then?

S: For malformations.

I: Malformation may occur in both groups.

S: Well a high percentage.

I: If it were possible, what might make an experiment that might be closer to the human situation?

S: If these Central American tribes were to give up the smoking and drinking, that wouldn't change everything like malformation would it?

I: Yes, probably it would, at least a percentage might change.

S: You might take them off that for a while, if they would.

I: Now I'm speaking there of a long period of time, like 50 years or so. Now you have chased down the smoking in pretty good fashion. Is there anything else that we might work on? Or any further you might want to go with it?

S: I don't think the drinking, if it was only the beverages from fruit... Well it could have been, I don't know what the drinks are made of. I know that they are made of fruits and berries and stuff, but these fruits and berries might have an effect on the people.

I: How would you go about determining this type of thing? Are you going to go around eating berries and so forth, fruits and this type of thing, as well as making drinks out of them, which they do?

S: I'd go and see how they made these drinks and processes and analyze what the drinks are made out of and see how much care was taken in making the drinks if they are sanitary or something like that.

I: Good, now don't forget I'm here as an information bureau, so ask anything you want.

S: This drink, was there...is there any kind of berry that's known to be... that's known right now to have effect, different effects on people?

I: Yes, there are substances of some berries...

S: I mean on the ones that they drink?

I: None that we know of.

S: So if the drink doesn't have any effect on the people that we can see...

I: You have a little colony and there are other people in other colonies around in the area, how might you use them to give you a little help?

S: Well, see if they drank the beverages and if they don't, why they don't.

I: They do.

S: They do?

I: That's good, go ahead.

S: Did the other colonies drink the same?

I: Most of them as far as we know. They vary a little bit but basically it's the same.

S: I wonder, do they have a smaller percentage than the ones that were smoking?

I: Some of them will and some of them will not. You asked me about the drinking; now you didn't say anything about smoking; that's another problem.

S: I asked you once what the other tribe smoked.

I: Some of them do, some of them don't.

S: Some of the tribes both drink and smoke the same things as this tribe does?

I: Yes.

S: And there was less percentage?

I: No.

S: It was the same percentage? So it looks pretty clear.

I: How do you go about knowing? You were running experiments on it; let's pursue that just a little further with animals. And I ask you, are there other ways that you could use these animals that might make the situation closer to the human situation than what you suggested?

S: You mean like if you lay this drink out would they accept it or something like that?

I: Yes we were talking about animal experiments and you were using mice and you got to monkeys and you were talking about what at that time?

S: I guess we were talking about smoking.

I: Could you set up an experiment that would be a little bit closer? You mentioned injection. Could you set up one that's even closer?

S: You could get the monkey to smoke the peyote and drink the juice, record his reactions in his offspring, what they were like and see the differences between the parents and the child.

I: Do you think that's possible?

S: I think you can look at the cells and tell if there's that much difference.

I: I mean, do you think it's possible to get monkeys to smoke?

S: I guess.

I: It is.

S: If they like it I mean.

I: That's what I've been trying to get you to answer me if monkeys can smoke. They have trained monkeys to smoke. You've pursued the question very well. Now summarize what you have done as far as this project is concerned.

S: From the information that I took from you I concluded that smoking was the cause of the high percentage of deformed persons. I could have gotten it from experiments on animals, teaching animals to smoke and testing and studying their different reactions.

Interview Number 5

Interviewer: You have the problem before you. Now see how you would solve that particular problem.

Student: After I read over it, at first I couldn't figure out what was the...if they were supposed to go together and I started thinking that they think maybe these deformities could have something to do with the things that happen to these villagers in their ceremonies. I figure that probably the people in the ceremonies were the deformed or retarded, like those babies were supposed to be. It says that the porportions of deformities found by the research team was 10 times as high as would be found in an average sample of persons in other areas of the world. I was thinking maybe something in this part of the world would make these babies deformed. Maybe the thalidomide babies somehow connected...maybe this drug you're talking about...the treatment...maybe it's in the plants or something. Would it be possible to find that in plants, that drugs?

I: In this particular area?

S: Yes.

I: This drug is not involved.

S: No. Well, I would state my guess that there is something then in this part of the world, in this part here, that isn't anywhere else.

I: Yes, see if you can analyze this. Is anything there that you could try to investigate that might cause deformities?

S: Would the smoking and drinking have anything to do with it?

I: They could. How would you go about determing this?

S: I'd see what they were smoking and the contents of what they were drinking.

I: All right, now you're going to run to your research center, so if you want specific information I can give it to you.

S: Is there any kind of drink or anything they could be drinking that would have something in it or smoking that would have something in it to cause deformities?

I: Take them one at a time now.

S: Okay. It's mainly the things they are smoking.

I: The substance they are smoking is known as peyote. It contains a drug that produces hallucinations.

S: I'd form a hypothesis that maybe what they are smoking and drinking are causing them to go into trances or so--called trances and that their ceremonies...

I: How could you determine this?

S: You said that it caused hallucinations. When they are in their circle, maybe a certain amount of this will make them go into a trance and wild expressions.

I: Could you determine this, say, from something that they might be drinking?

S: You say they are drinking something other than water? They make their drink themselves?

I: Yes.

S: I guess I'll ask you maybe the contents of the stuff they drink here.

I: Made up? It's made up basically of the fruits of the area and juices from cactus plants.

S: Would the soil have anything to do with the drink, with maybe something in the drink.

I: What makes you determine that the soil had anything to do with it?

S: The soil had something, maybe some kind of a substance that would be taken into the plant.

I: How could you determine whether this was being done or not? Is there any way you could get to the problem to solve that?

S: I would think that analyzing the soil...

I: Possibly, yes.

S: Does the particular plants in it have anything to do with it or just the makeup of it all together?

I: Ask a specific question there, and I could answer you.

S: Is one specific plant supposed to have...could have something in it to cause this, or would it be the combination of the plants in the drink?

I: To cause the hallucinations or what?

S: To cause something to the nerve system or something.

I: Does this involve that which is the drink?

S: Yes, in the drink.

I: No, there wouldn't be.

S: Does that cross out the drinking then? The drinking has something to do with it?

I: Could you show that it does in some way?

Interview Number 6

Interviewer: Begin as logically as you can to solve the problem. Remember any information that you would like to have, I'll give to you.

Student: After the tour of the village, after they saw that a lot of people were deformed, and they noted a similarity to the thalidomide babies in Germany, I'd try to find out if there is any similarity in any chemical which they were smoking or drinking; if there is anything similiar to to the thalidomide and it's being wild, and if there were any places other than that particular village where these deformed people are. Since they say that they are 10 times as high as what they found, if just that village was smoking and drinking, that might be the cause of it. If any other village didn't but a portion had this...

I: Fine, how would you go about doing this?

S: I'd find out what was in what they were smoking and drinking.

I: How would you find out what they were smoking and drinking?

S: Probably the best way is analyze something.

I: How would you do this?

S: I suppose do some kind of lab test.

I: What type would you suggest?

S: What type?

I: How would you go about setting up the lab test? What would you want the laboratory to tell you?

S: What were the main substances in what they were smoking and drinking?

I: No, you want me to help you. You have to ask me the particular question and I'll try to answer it for you or do as the laboratory would do. If you had to work this out in a laboratory you would have to figure out just exactly what you were going to try to test for and how you would go about it. You build your procedure, and then I'll, if you want me too, try to give you the results.

S: I'd run a test for thalidomide on the stuff they were smoking and drinking.

I: You would want the laboratory to tell you whether there was thalidomide there?

S: Yes.

I: Now do you want me to tell you what the results of that would be?

S: Yes.

I: Your laboratory test would tell you there was no thalidomide.

S: Okay. Then I'd see if there was any particular food they might be eating in that region if that area...no other area in particular...had thalidomide in it.

I: How would you find this?

S: I suppose the same way--analyze it.

I: It would be quite difficult to analyze different areas. Could you use another method?

S: Well, see, it's kind of a different way of going toward this problem to see if the deformed children were the children of people who were going to the trances. And that way, I guess we'd just have to observe to find out what the children...and see what connection the trances had with the deforming.

I: What observation would you make?

S: I think first the...just observe the people that were in these trances. Just see what they are like that way, and then find the children who were deformed and see if they were related to the people who were going to this trance, and if there's a relationship, then...

I: How would you do this?

S: Observation, I mean you'd have to, lets see...

I: Their available for interview, would that give you an idea?

S: Yes, you could ask the people, you know what I mean.

I: This is concerning new relationships. What information do you want now?

S: I want the information whether or not the deformed children were the children of the people going to the trance?

I: Yes they were.

S: Well, what relationship were they...just the children or any other relation to them?

I: Children. Also it would be found that most of the people of the little colony would go into these trances at different times.

S: Then, I think probably, there is something--maybe not thalidomide--but something else in what they were smoking or drinking that was causing them to go into this trance. Then would that be what the children

would inherit...and then lets see...probably not thalidomide but probably something similiar to thalidomide with the same general effects. I guess we'd run the tests for something similiar to thalidomide.

I: Now you have a kind of hypothesis here. You have something set up, but you have to restrict it, or you could tell the laboratory what you want to test.

S: I'd want to test the substance that they were smoking and drinking to see if either of them--either of the two substances--had anything in them which is similiar to thalidomide.

I: Do you want to ask me what they are or what the results were? Which one?

S: You mean which one of the two? What were the results of the substance they were smoking?

I: The substance they were smoking was a substance that is known as piaote or peyote, it's from a cactus and it has a hallucinatory effect on individuals.

S: Was it similiar to thalidomide in any way?

I: Not thalidomide, no.

S: Well then how about the substance of drinking; was this similiar to thalidomide?

I: No.

S: The substance they were smoking, probably then, since there is a hallucinatory drug...it would be...I would see if the...since the substance they were smoking, the peyote, had the hallucinatory effect, I think I'd probably...the smoking had an effect on the cause of the trances. Of course then I'd have to kind of see if these trances that the people were in, if these were caused by the smoking and had an effect on the deformed. Probably the first thing to do is to find out how the...if the smoking--the peyote--had the effect on the--or caused--the trances, the hallucinations. How would we do that? I guess we would have to find out...is there any way to find out if a certain drug or anything had an affect or if it is the thing that causes the trance or hallucination?

I: Yes, there are ways of finding out.

S: What are they?

I: Can you think of any.

S: Probably take the peyote tested on some laboratory animal--onwhite mice or something.

I: Good. See if you can set up an experiment that would work.

S: I'd have maybe a mouse with...that would just be given a certain amount of water, and so on, and not the peyote, and one would be given the same amount of food and water but with peyote, and see there was any particular affect on the mouse with peyote.

I: How would you give them the peyote?

S: I don't know. Any suggestions on how to get him to bite?

I: Your experiment should be fairly similiar to the actual condition of the people. Could you think of any way you might make the experiment, or what you talking about, be similiar to what the people were doing as far as peyote was concerned?

S: Well, they were smoking it. I suppose they'd be inhaling it, so then the mouse would have to inhale too. Just inhale it by, I suppose, burning it and inhale the smoke from it.

I: Continue on with that experiment. Where would you keep the mice?

S: We'd have to keep them in the same...what do you mean by where do you keep the mice?

I: You have to expose them to the smoke. How would you set up the experiment so that you could accomplish what you wanted to accomplish?

S: The two mice would have to be isolated for one thing so that they wouldn't get any of the effects of the one--get any effects of the peyote. I don't know how we could do that.

I: Go ahead; you're doing fine. You have the mice isolated; what's your next step?

S: It would be to get the one mouse to inhale the...but you'd just have some way of,...just like the people in the village would smoke it. Like have it burning or smoldering near enough to the mouse for him to inhale it. Then see the affects on that one mouse.

I: The results of that would be that the mouse would be affected through inhaling.

S: Would the mouse be affected in any way that the people were--they assumed strange posture? What did the mouse do?

I: The mouse would feel periods of not being conscious of whats around him, physically. Perhaps he would be seeing things that were not present, acting peculiarly as far as general movements are concerned.

S: Then, I suppose the peyote probably caused the hallucinations. Now the next step is to find out how this...why this would effect the children

that were deformed. I think maybe...couldn't they run the same test with the mice and see if it affected the mice; pregnancy that would affect the mice.

I: Fine, now set it up for us.

S: I'd breed the mice, not the two mice together, but separately, and just see how one mouse had been affected and one that hadn't and if it had any effect.

I: You mean take a mouse in the cage which had been given the smoke and breed it to one that had not.

S: That's what I'm trying to figure out. Lets start at the control. Just breed two mice which hadn't been affected; then you've got the one which was. Since probably most of the people in the village had been affected by this, I'd breed two affected mice since probably both parents of many of the people who were deformed probably had been affected. I would see if the offspring of the mice which hadn't been affected were normal or not, or which percent was normal and which was not.

I: Would you use just one set of mice?

S: Probably several sets each from the control. For instance maybe a couple of people may have been affected by this but maybe it didn't affect the children of some. So I'd use maybe four sets for the control and four that had been affected, and see what percentage of all the mice were affected. I suppose I'd go back to the lab for the results.

I: The result would be we don't know the answer. Using this, two would this apply back to the population?

S: What do you mean how would it apply to the population?

I: I might mention two things. There is a difference in just plain breathing smoke and actually holding in the mouth a cigarette made out of peyote. Some material might be lost. For the mice, you'd dilute the smoke in the air; you might actually lose the affect because of the diluted smoke, if there were to be an affect. Can you think of a modification which would more closely parallel humans.

S: Since there's actual contact between the peyote and the person, it probably enters the bloodstream, maybe if they had a cut in the mouth or something. Would that be...?

I: It's possible, but perhaps you find most of them with fairly normal mouths.

S: Okay.

I: You were using animals; I merely brought you back to humans, not to deviate from your experiment, but lead you to another area of research you might perform.

S: Try to perform the same experiment on the people from a neighboring village that didn't have this peyote.

I: This is difficult to do with humans. Is there some other animal that could be used besides a mouse?

S: Maybe a chimpanzee or something that's similiar to a human. You'd have the same basic experiment...expose them or whatever to...we'd have to see if it would have an affect on them like it did on the humans or like it did on the mice. Maybe it wouldn't have an affect on the chimpanzee so I'd run the experiment just to see if it had an affect. Give one chimpanzee just what's necessary--food, water and everything; give the other one the peyote and see if they were affected.

I: How would you give them peyote?

S: That's what I'm trying to see. Chimpanzee's imitate a lot. I don't think that would work, I don't know what to do.

I: That thought you had...

S: If chimpanzees saw people smoking peyote probably the chimpanzee would try since they imitate a lot. If the chimpanzee would smoke the peyote, see what the effect would be on the chimpanzee. What effect would there be on the chimpanzee?

I: I don't have your experiment set up.

S: One chimpanzee was isolated with just food and water and without the peyote; the other was given the same amount of food and water but also the peyote and observed to see what affect it had.

I: You want the chimpanzee to smoke?

S: Yes.

I: Do you want the results or do you think this is possible?

S: I think it's possible. I want the results.

I: The results of what?

S: Of what affect the peyote had on the chimpanzee.

I: You can't train chimpanzees or monkeys to smoke.

S: Okay.

I: Secondly, you would find a hallucinatory effect.

S: If the chimpanzees had hallucinations, then I would breed several sets of chimpanzees which didn't have the effects and some which to see what percentage of offsprings was deformed.

I: Fine.

S: I go back to that laboratory and find out?

I: Yes. We don't know the results, but you developed your experiment well. Let's say we're not sure of the results but you did find abnormalities in the offspring, then what?

S: Well if deformities were found in the offspring of the chimpanzees exposed to the peyote and not in the others, then I'd assume that it had an affect on the offspring.

I: Now suppose you found the effects in both?